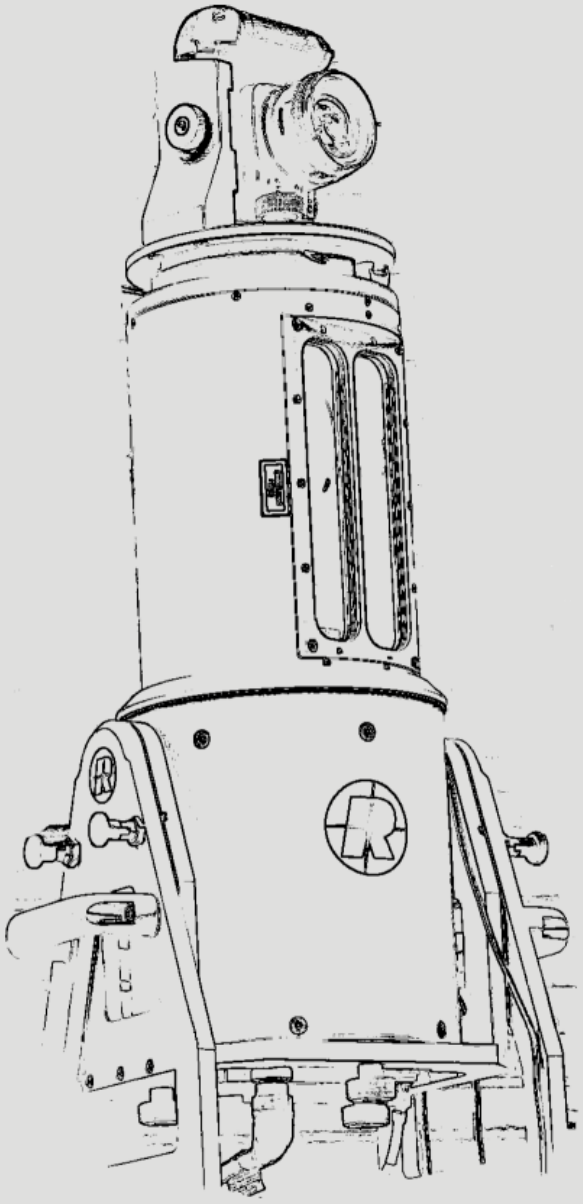


RiSCAN PRO

www.riegl.com

Version 1.2.0sp1

RIEGL
LASER MEASUREMENT SYSTEMS

RiSCAN PRO

Printed: July 2005.

Table of Contents

Part I

Introduction into RiSCAN PRO

1 Introduction into RiSCAN PRO

RiSCAN PRO is the companion software package to the RIEGL 3D laser imaging sensor of the LMS-Z series. It allows the operator of the 3D imaging sensor to perform a large number of tasks including sensor configuration, data acquisition, data visualization, data manipulation, and data archiving using a well documented structure.

RiSCAN PRO is project oriented. All data of a project is stored within a single directory structure containing all scan data, calibrated photographs, registration information, additional descriptors and processing outputs.

We publish our project structure to allow our software partners to directly access all useful data gained within a scan project. The structure of the project is stored in a text based- and documented project file making use of the XML language (see "Data exchange: Fileformats: RSP 197"). The name of the project file is "project.rsp". Within RiSCAN PRO all data is organized in a tree structure for comfortable access and clarity.

Part II

Installation

2 Installation

2.1 System requirements

Before you install RiSCAN PRO on your PC please make sure that the system meets the following requirements:

Operating system:
Windows 2000, Service Pack 2 or above
Windows XP (Professional recommended)

Memory requirements:
256 MB RAM minimum,
1024 MB or more recommended

Disk space requirements:
approximately 30 MB for the program
approximately 700 MB for the example project (only included in the CD version of RiSCAN PRO)
at least 40 GB recommended for own projects

Interface for scanner communication:
Serial and ECP parallel interface or alternatively ethernet (LAN) interface

Graphics requirements:
OpenGL accelerated graphics card
nVIDIA GeForce series recommended (GeForce2 or better)

Peripherals:
3 button mouse, optical wheel mouse recommended

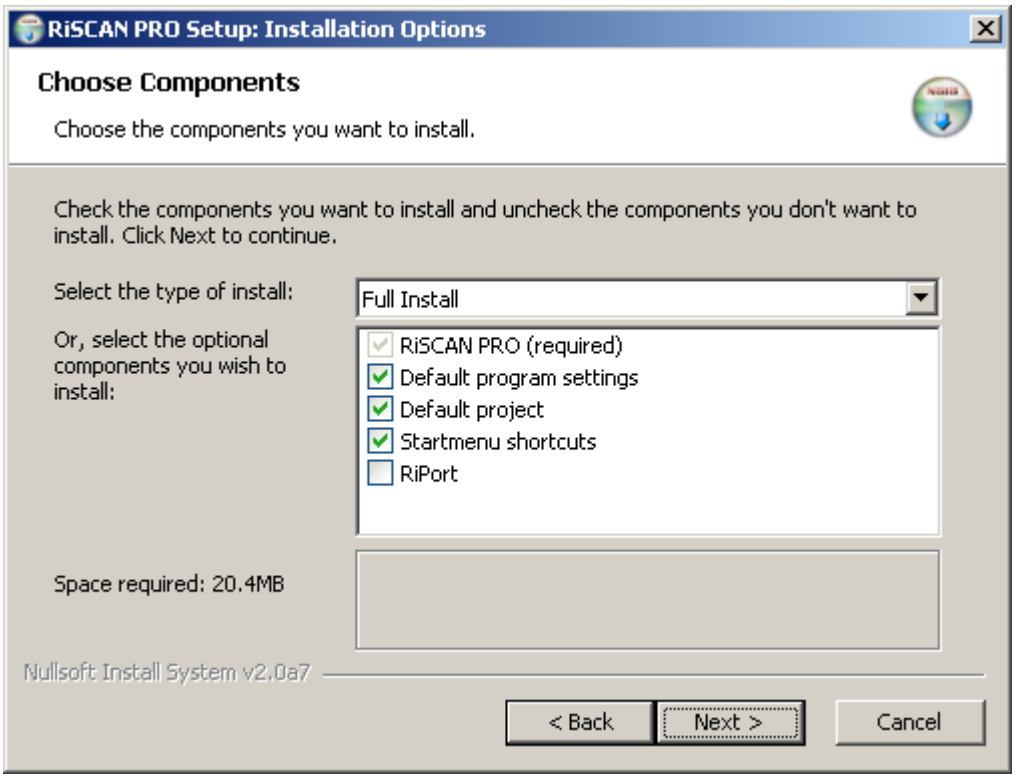
2.2 Program installation

To install RiSCAN PRO on your system just run "SetupRiSCAN_PRO.exe".
This program will guide you through all parts of the installation process.

Steps of installation:

- **License - agreement:**
  At first of all you will be prompted to accept the license - agreement.
  Press on the button "I agree" in order to accept the license and continue the setup.
  Otherwise the setup will be aborted without installing RiSCAN PRO.

- **Component selection:**



At this dialog it is recommended to select the "Full Install" option to make sure that all components will be installed.

Component description:

- **RiSCAN PRO (required)**
  The application itself

- **Default program settings**
  This option is only of interest when you update RiSCAN PRO to a newer version. Disable this option to keep your program settings. Otherwise they will be overwritten with default values.

- **Default project**
  Contains a RiSCAN PRO project with default camera calibrations and camera mountings.
  The default project will be copied to the selected project folder which will be defined on the next page.

- **Startmenu shortcuts**
  Add shortcuts (links) for RiSCAN PRO to your startmenu.

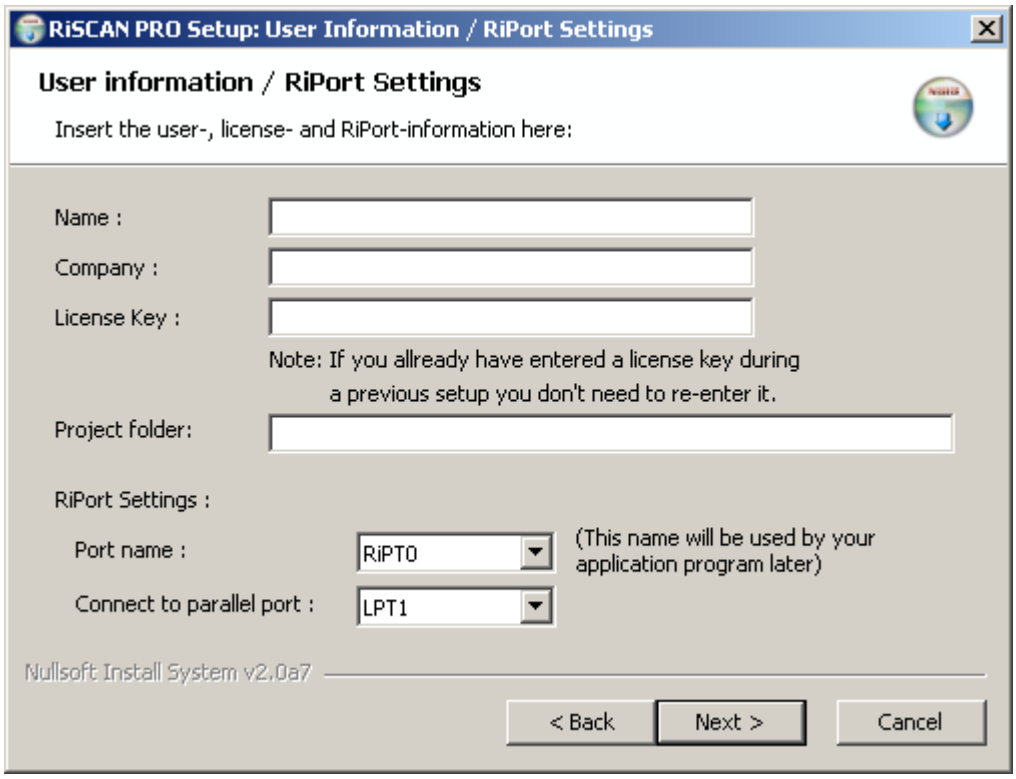
- **RiPort**
  This installs the RiPort driver on your system.
  Note: RiPort is **not** needed on PCs with MS Windows95/98 or if you do not intend to use the parallel port for data acquisition.

  If setup detects that RiPort is already installed, you will be asked whether the installed driver or the driver of the RiSCAN PRO package should be used.

  If you decide to use the driver of the package, the old driver is deinstalled and the new driver is installed.
  Note: This will result in rebooting the system twice.

More information about "RiPort" 205

- **User information / RiPort settings:**



- **Name & Company:**
  Enter your name and company name here.

- **License key:**
  Enter the license key here.
  The license key can be entered with or without the dashes ("-") between the numbers.
  Also the characters can be uppercase or lowercase ("A" or "a").

  If you do not enter a license key you can use the license manager 10 of RiSCAN PRO to manage your licenses later.
  If you do not enter a license key a default viewer license key will be installed which allows you to run RiSCAN PRO but you are not able to acquire data.

  Note:
  If you just update RiSCAN PRO to a newer version you do not have to enter a license key because the "old" one(s) are taken.
  The license keys of RiSCAN PRO are saved in a per-user manner. Therefore every windows user has to enter the license key in order to run RiSCAN PRO.

- **Project folder:**
  Enter the folder where the projects and the default project (if selected) should be saved. The default folder is "Riegl Scans", located in your documents folder. You can also modify this folder in the Program settings 24.

- **RiPort settings:**
  Select the port name of the new RiPort and the parallel port it is assigned to.
  The setup-program will install the RiPort-Driver and add a new RiPort with the given settings.

  -> More information about "RiPort" 205

  Note:
  If you select to NOT install RiPort, "RiPort settings" will be shown but disabled (the lists only contain "not used").

- **Installation Directory**

  On this page you can choose the folder, where RiSCAN PRO should be installed to.
  The default folder is "Riegl_LMS\RiSCAN_PRO\" in your applications folder.

- **Complete installation**

  By clicking on "Install" on the "Installation Directory" page the installation is completed.
  Now all needed files are copied on your system.

2.3 License manager

To run RiSCAN PRO it is necessary to enter a valid license key once. This can be done during the installation 7 or anytime while RiSCAN PRO is running.
The license keys of RiSCAN PRO are saved in a per-user manner. Therefore every windows user has to enter the license key in order to run RiSCAN PRO.

Generally a key has two criteria:

- **Time**

  - *unlimited*
    This key has no date of expiration.

  - *limited*
    This key is only valid till a certain date. After this date (and no other valid license key is available) you can not work with RiSCAN PRO. (On startup the license manager appears.)

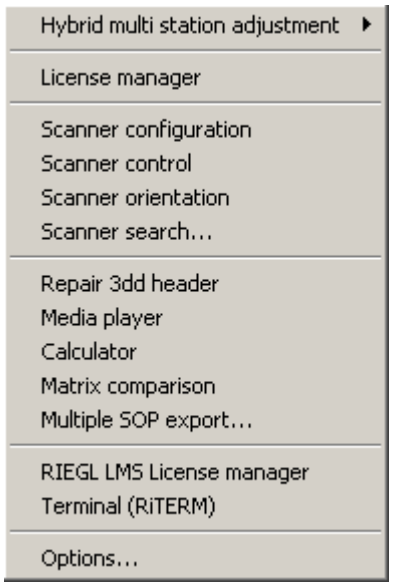
- **Device**

  - *HDD-Lock*
    The key is only valid on a PC with a certain harddisk-ID. In this case RiSCAN PRO works with all RIEGL LMS-scanners.

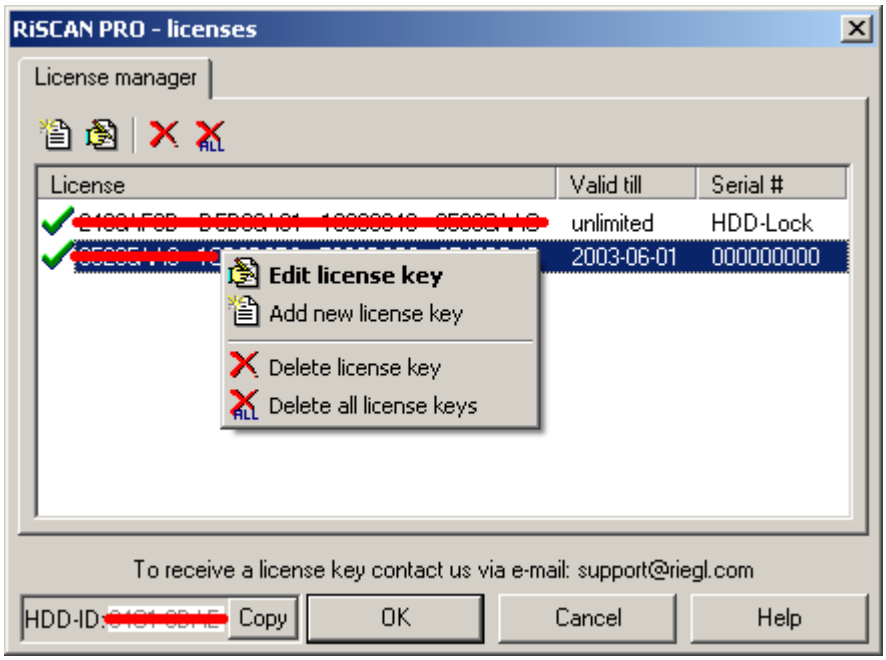
  - *Device-Lock*
    This key in only valid in combination with a certain scan device. In this case you can start the program, but you can only work with the scanner determined by the key. Connections to other scanners will be refused.

  - *Dongle-Lock*
    Alternatively a USB dongle is available. The advantage of the dongle is that you can work on any PC equipped with a USB port with just one license key and all instruments.

With the built-in license manager of RiSCAN PRO you can add, edit and delete licenses of RiSCAN PRO.
To show the license manager click on "License manager" in "Tool"-menu of RiSCAN PRO.



The license list shows currently existing license keys for RiSCAN PRO.



The icon near to the license key shows the state of the license key:

..... the key is valid
..... the key is NOT valid

- **Adding a license key:**

  By clicking on "Add new license key" a new dialog appears, where the new license key can be inserted.

  Note:

It doesn't matter if you enter the license key with or without the dashes ("-") and blanks (" ").
Also the case of the characters isn't important.

- **Editing a license key:**

  Select the license key by clicking with the mouse on it.
  Click on "Edit license key".
  A dialog appears, where the license key can be edited (see format notes at "Adding a license key" 10).

- **Removing a license key:**

  Select the license key(s) you want to delete.
  Click on "Delete license key".
  The selected license key(s) will be deleted without confirmation.

- **Removing all license keys:**

  Click on "Delete all license keys".

  Note:
  There is no confirmation ("Do you really want to...")! The keys will be deleted and can not be restored.

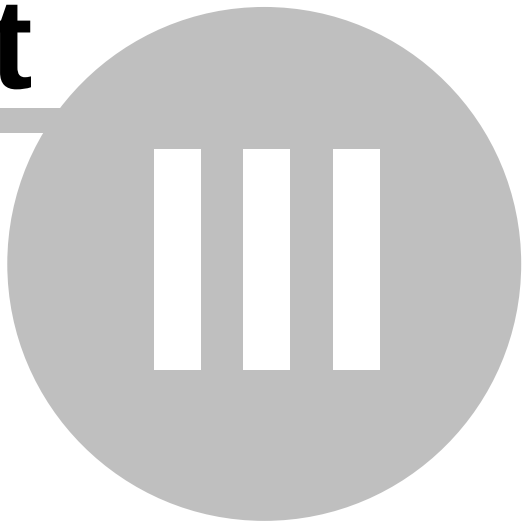
- **How to get the HDD-ID:**

  In the bottom left corner of the license manager is a box showing the HDD-ID of your PC. By clicking on the button "Copy" the HDD-ID is copied to the clipboard in order to be used in an e-mail to support@riegl.com.
  (The HDD-ID is also shown in the "about-box" of RiSCAN PRO.)

Note:
If there is no valid license key left when you close the license manager you will be prompted to add a license the next time you start RiSCAN PRO.

Note:
The built-in license manager of RiSCAN PRO only shows the licenses of RiSCAN PRO. To edit the license keys of any other RIEGL LMS software product or either a plugin of RiSCAN PRO you have to use the "RIEGL LMS License manager". You'll find this program either in the start menu in the group "Riegl LMS > Support" or in the "Tool" menu of RiSCAN PRO. This program doesn't display whether the installed license keys are valid or not due to security reasons.

Part

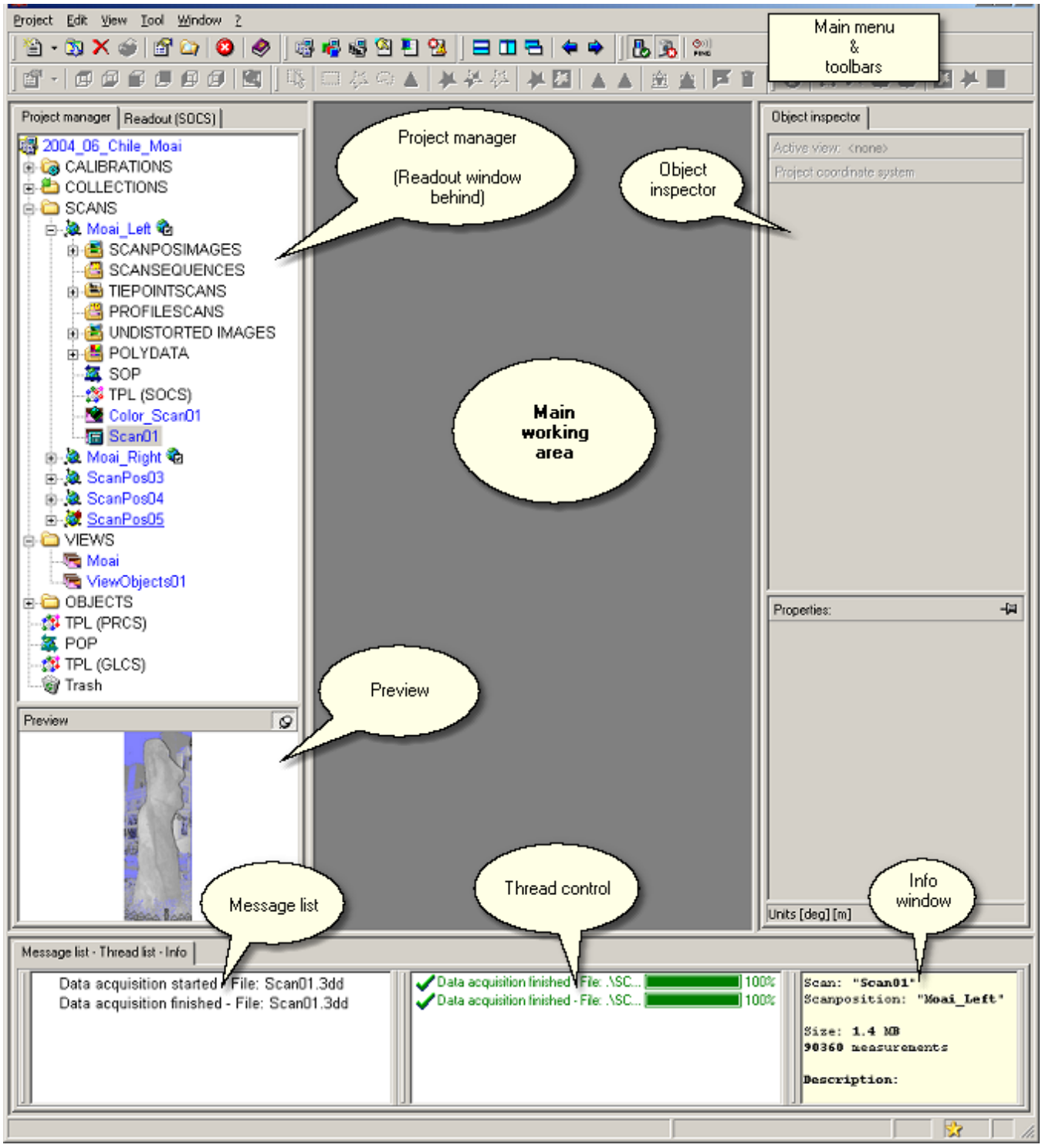


Getting started

3 Getting started

3.1 Main program window

The main window of RiSCAN PRO is modular. You can decide which tool windows should be displayed and where they should be placed. The configuration (visibility and position) will be saved on shutdown and restored the next time you start RiSCAN PRO. The following screenshot shows RiSCAN PRO with a default configuration:



Tool windows of RiSCAN PRO

- **Project manager**

  This window shows a so called "tree view" of the project structure. This tree view contains all items (scans, images, configurations, calibrations and so on) saved in the project. To modify an item click with the right

mouse button on the item and select your desired action from the menu.

Shortcuts (within the project manager window):

Enter	perform default action (e.g. view a scan, open the tiepointlist,...)
ALT + Enter	shows the file attributes of selected object (the standard Windows dialog will be displayed)
CTRL + Enter	open selected object in Windows explorer (file path)
F2	rename selected object

- **Preview window**

  This window is positioned on the bottom of the project manager and shows a thumbnail of the currently selected scan or image. You can open and close the preview window by clicking on the pin beside "Preview:".

- **Message list window**

  This window shows all messages created by several functions of RiSCAN PRO. These messages are saved with the project, thus you have a complete summary of all actions done in this project.

  Message examples:
  Project loaded, Project loaded (read only)
  Project saved
  Data acquisition started
  Data acquisition finished
  ...
  and also information, warnings and errors.

  Note:
  The number of messages in the message list is limited to 5000. Everytime this limit is reached the first (=oldest) 1000 messages are deleted.

- **Thread control window**

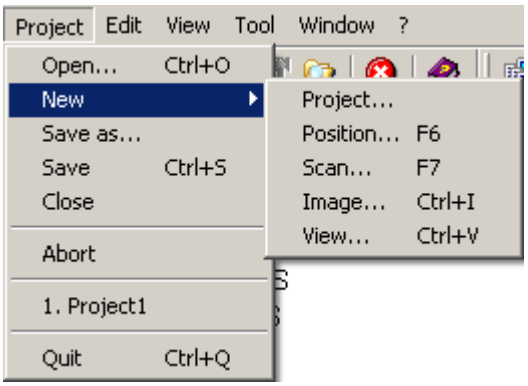
  This window shows a list of all running threads. A thread is a process which may last very long such as data acquisition or image acquisition. These threads are running in the "background" so you may continue working with RiSCAN PRO, although in a restricted manner. Note, that a running thread can lock items of the project tree in order to avoid errors by changing values during the process. You can not save or close the project neither quit the program as long as threads are running and items are locked.

- **Info window**

  This window shows some information of the currently selected object such as number of points, file size and so on.

The main menu of RiSCAN PRO:

- **Project menu:**

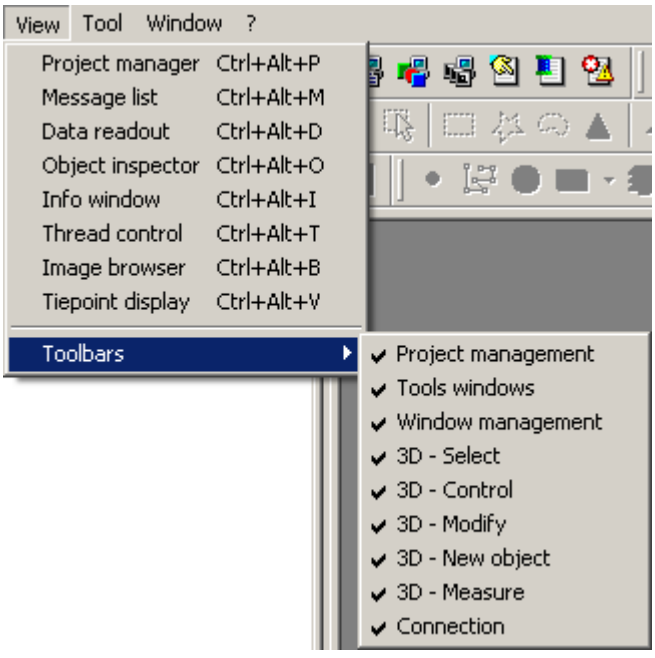


In this menu you can load, save or close a project.
The menu item "Abort" will quit all currently running threads like data or image acquisition.
With the submenu "New" you can either create a new project or create new items (scans, views, scan positions, images) in the project.

- **Edit menu**

  This menu offers actions like edit, rename, show attributes, delete, and so on, that can be done on the currently selected item of the project-window. The number and kind of actions offered depends on the selected item. This menu is identical with the menu that appears when you click with the right mouse button on an item of the project manager.

- **View menu:**



With this menu you can open the following windows (if they are not already opened):

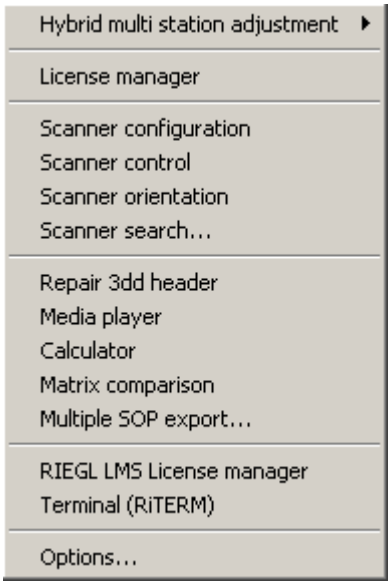
- Project manager 14
- Message list 14
- Data readout 118 (can be opened more than once)
- Object inspector 108

- Info window 14
- Thread control 14
- Image browser 122
- Tiepoint display 121

and the following toolbars:

- Project management 14
- Tool windows 14
- Window management 14
- 3D - Select 143
- 3D - Control 117
- 3D - Modify 144
- 3D - New object 170
- 3D - Measure 177
- Connection 14

- **Tool menu:**



Hybrid multi station adjustment

This menu is only visible when the HMSA-plugin is installed (see "Hybrid Multi Station Adjustment 141").

License manager

Shows the license manager (see "License manager 10")

Scanner configuration

Shows the configuration dialog to configure the scanner without acquiring a new scan (see "Scan acquisition 65").

Scanner control

Shows a dialog to manually move the scanner.

- *Move*

  use the bottons with the arrow to move the scanner in the resembled direction. Pressing the button "Halt" (center) will stop the movement. Alternatively, use the following shortcuts:

  "A" -> turn left
  "D" -> turn right
  "W" -> turn up
  "S" -> turn down

- *Angles*

  provides information about the current alignment of the scanner. Press the button "Get position" to refresh the information.

- *Align*

  Enter an angle for Theta (vertical alignment) and Phi (horizontal alignment) and press the button "Align" to manually set a position for the scanner.
  The button "Set park position" will reset the scanner to a defined position (Theta: 0°, Phi: 180°).

Scanner orientation

With this tool it's possible to use the optional inclination sensors of the instrument to align the instrument (see Inclination sensors (optional) 71).

Scanner search

You can use this tool to search for an instrument connected to the same network as the PC or even if the instrument is directly connected with the PC via a cross over network cable. This function might be useful when you don't know the IP address of the instrument.

To search for the instrument on the complete local area network click on the button "Start search". You may also limit the search to a fixed IP address range by clicking on "Search IP from" and entering the IP addresses (only when no search is currently running).
All found instruments on the network will be displayed on the list in the center of the window. The columns of the list show the IP address, the serialnumber and the name (type) of the instrument. To apply the IP address to the communication settings of the currently opened project, select the instrument from the list and click on the button "Apply".

Note:
The search time depends on the network speed, network load, number of network instruments connected and the selected address range.
The button "Apply" is activated only when an instrument is selected and a project is loaded.

Repair 3DD header

To get higher accuracy some corrections are applied to the raw data measured by the instrument. These corrections are described by a lot of parameters determined in the factory and saved in the data file gained by the instrument (the 3DD file). In case of any misadjustment of the instrument, the point data is not correct due to wrong correction parameters. To solve this problem it's necessary that the instrument is recalibrated in the factory. The data files already acquired by the instrument (while it was misadjusted) possibly can be repaired by this tool. After recalibration in the factory a template 3DD file is generated containing a new set of calibration parameters. This template file can be applied to the faulty scan files. To do so please proceed as follows:

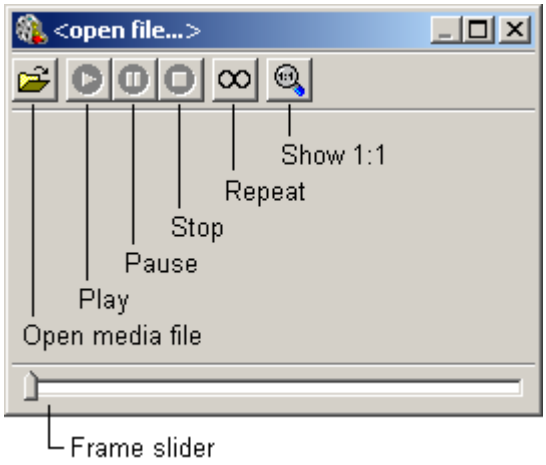
- Open the project containing the faulty scan(s).

- Start the "Repair 3DD header" tool from the "Tool" menu.
- Select the "SOURCE SCAN". This is the template scan file provided after recalibration in the factory.
- Select the faulty scan files to repair.
- Click on the button "OK" to start the reparation.

Note:
This function is only applicable to acquired scans (not colored or resampled) with the same type of header (preferably the same instrument)! Furthermore it depends on the kind of misadjustment, whether you can use this tool or not.

Media player

The built-in media player of RiSCAN PRO is able to play the following media file formats: AVI, WAV, MP3



If the playback of an video file is running (AVI) the video will be stretched/shrinked according to the size of the window. To show the video 1:1 (100%) click on the button "Show 1:1".

Note:
Whether the media player is able to play a certain sub type of the AVI format depends on the installed video codecs. Please contact the distributor of the video file in order to get the correct video codec.

Calculator

The calculator is a tiny tool which enables you to calculate quickly the sum or difference between two or more values such as surface areas or volumes. To add a value to the calculator just drag the value from the project manager and drop it onto the list. To change the sign of a value, select the value from the calculator's list and click on the button "+" or "-". On the bottom of the calculator window the result of the calculation is displayed.
If you want to save the result click on the button with a small floppy disk on it.

Example: You want to calculate ValueA - ValueB. Proceed as follows:

- Open the calculator
- Drag ValueA and drop it onto the calculator (it gets automatically a "+" in front of it).
- Drag ValueB and drop it onto the calculator
- Select ValueB in the calculator
- Click on the button "-"
- The result is displayed on the bottom of the calculator window

To copy the result to the clipboard (e.g. in order to use it MS Excel) click on the second button from right.

To force a recalculation of the result click on the third button from right.
To remove a value from the list select the value first and click on the third button from left (with the red X on it).

Note:
You can only add values of the same unit to the calculator. That means, if the first value added to the calculator represents a surface area you can only add further values of type "surface area" and so on.

Matrix comparison

With this tool you can compare two matrices. The difference will be displayed as offset in X, Y and Z direction and as rotation about X, Y and Z axis. To load a matrix into the tool just drag a COP, SOP or POP matrix 202 from the project manager and drag it onto one of the both matrix grids. As an alternative you can also click with the right mouse button into the matrix grid and select "load" from the menu. When two matrices have been loaded click on the button "Calculate" in order to calculate the differences.

Multiple SOP export

You can use this tool to export all orientation and position matrices (SOPs) of all scan positions of the current project at one step (e.g. for analysis in MS Excel). On the left side of the window ("TARGET FOLDER") you can select the destination folder (this is where all exported files will be saved). On the right side ("scan positionS") you can select the scan positions of which the SOPs should be exported. To control which files should be generated you can use the three boxes in the bottom right corner ("EXPORT SETTINGS"). Possible file formats are: .SOP 195, .DAT 196 and .ROT 196. To start the export click on the button "OK". For each selected scan position the files will be saved to the target folder whereas the filename corresponds with the name of the scan position.

RIEGL LMS License manager

This tool manages the licenses for all Riegl products (it can be also reached via Start -> Programs -> Riegl LMS -> Support -> License manager).

Terminal (RiTERM)

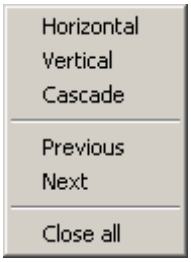
This tool is a terminal program for testing a connection (it can be also reached via Start -> Programs -> Riegl LMS -> Support -> RiTERM).

Options...

Shows the dialog "RiSCAN PRO Settings" (see "Program settings 24")

- **Window menu**

This menu will arrange the windows in the specified manner.



- *Horizontal*

  the windows are aligned in a horizontal manner.

- *Vertical*

  the windows are aligned vertically.

- *Cascade*

  the windows are aligned behind each other.

- **?**

This menu will provide the help file and some wizards to guide you through the program.

- Contents

  This will open the help file. It can also be reached by pressing the key "F1".

- Wizard "Startup"

  This wizard will guide you through the steps for a basic configuration of RiSCAN PRO.

- Wizard "New camera calibration"

  This wizard is used to create a base camera calibration used to start a new camera calibration task (see "Base camera calibration 42").

- Save screenshot

  this will create a screenshot and save it to a specified directory and file.

- OpenGL info

  Shows some information about graphic card and graphic driver.

- About

  Provides basic information about the current version and RiDRIVERs installed.

The toolbars of RiSCAN PRO

To view the different toolbars, select View -> Toolbars from the main menu and select a toolbar from the list.

The meaning of the different symbols and their usage will be explained in the specific documentation of the function it is used for.

Project management:

- *New*

  When a project is already opened, pressing the symbol will show the "New Scan 65" dialog, otherwise the new project dialog will appear.
  pressing the arrow will show the menu "New..." 14.

- *Open*

  Shows the dialog to open a saved project.

- *Delete selected item*

  Deletes the currently selected item of the project manager (scan, image, scan position, and so on).

  Note:
  If the trash can is activated the object will not be deleted permanently, but moved to the trash can.
  To restore deleted objects, double click on the item "TRASH" in the project manager, select an object and click on the button "undelete".
  Please refer to chapter "Program settings 24" to see how to activate the trash.

- *Print*

  You can print a report of the current project.

- *Attributes of the selected item*

  Shows the attributes of the currently selected item of the project window (scan, image, scan position, tiepointlist and so on).

- *Cancel*

  Use this button to cancel the current process (data or image acquisition).

- *Help*

  Shows this help file.

Tool windows:

- *Show project manager 14*
- *Show object inspector 108*
- *Show tiepoint display 121*
- *Show data readout window 118*
- *Show message list 14*

Window management:

- *Arrange windows*

  Use these buttons to arrange the windows horizontally, vertically or overlapped.

- *Previous/Next window*

  Use these buttons to quickly switch to the previous or next window.

Connection:

This tool can check the network (TCP/IP) connection of the scanner and the camera server (see "Creating a new project 32"). For that purpose RiSCAN PRO sends a ping to the specified network address and waits for the echo of the scanner or camera server. If an echo is received within a certain time it's assumed that the connection is OK and a small hook appears on the button. Otherwise a small "x" will be displayed in order to show that there's something wrong. If the tool is deactivated or it's waiting for the first response a small question mark will appear on the button.

- *Network connection state of scanner*

  To activate the tool click on the button with the scanner on it (the button will stay pressed).
  To deactivate it click on the button again (a small question mark appears on the button).

- *Network connection state of camera*

  To activate the tool click on the button with the camera on it (the button will stay pressed).
  To deactivate it click on the button again (a small question mark appears on the button).

- *Interval for network-connection-check*

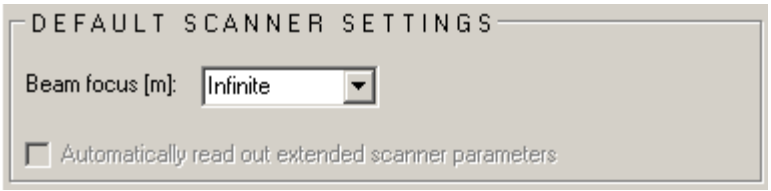
  Click on this button to set the interval of the connection check.

Note:
This is just a simple tool to check the network connection. It only checks IF something responds to the ping but it doesn't care WHAT responds. That means if you enter the network address of an other PC instead of the address of the scanner, the tool would pretend that everything is OK but communication with the scanner will not be possible unless you enter the correct address.

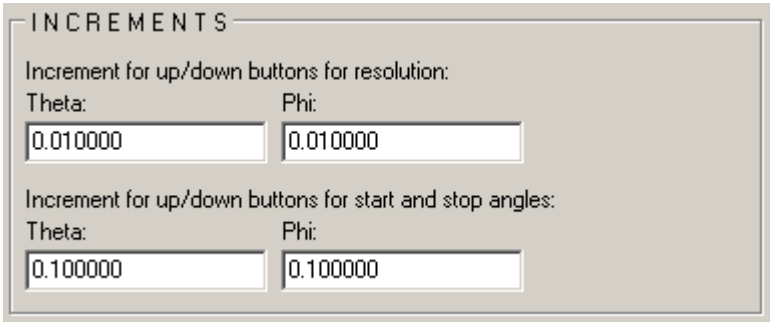
3.2 Program settings

In the RiSCAN PRO settings dialog you can set several options.

- **General - Default scanner settings**

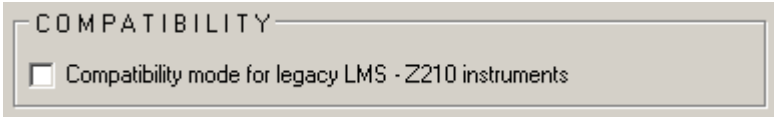


Beam focus:
This beam focus is used when you select a "Overview 69", "Panorama 70" scan.



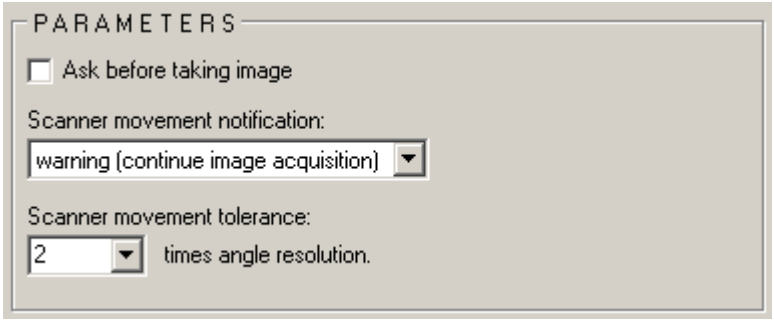
Increment for up/down buttons for resolution:
The value for the resolution degrees in the New Scan 65 window is increased/decreased by the amount set here each time the arrow is pressed ( ).

Increment for up/down buttons for start and stop angles:
The value for the resolution degrees in the New Scan 65 window is increased/decreased by the amount set here each time the arrow is pressed ( ).



Some older LMS Z210 instruments are not capable of high pulse-repetition-rates. Activate this option to reduce the rate (A too high rate results in a higher number of invalid measurements).

- **General - Image acquisition**



Ask before taking image
If you will be asked before taking an image during an image acquisition, then activate this option.

Scanner movement notification
During an image acquisition the position of the instrument will be read out twice for every image taken. Once before taking the image and once after the image was taken. The two positions will then be compared each other.
You can choose from three options what should happens, if the deviation is larger than a specified amount (*Scanner movement tolerance*):

- deactivated ... nothing happens.

- warning (continue image acquisition) ... only a warning is printed into the message list.
- error (abort image acquisition) ... the current image acquisition will be aborted.

- **General - Optional**

Some optional settings.

- **General - Tiepoint scan**

See Reflector extraction (Scan) 73.

- **General - Units**

Define physical units used in the whole program.

Angle:
- Degree (deg)
- Radian (rad)
- Gon (gon)

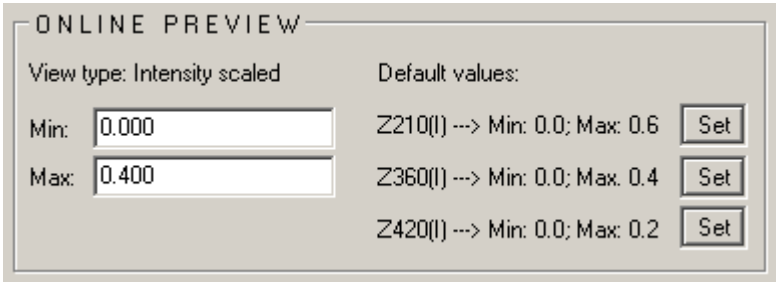
Range:
- Meters (m)
- Feet (ft - 1ft = 0.3048m)
- US-Feet (ft - 1ft = 12/39.37m)
- Yards (yd)

Amplitude Scale Unit
- 0...1
- 0...255

- **Additional - Default viewtype**

Sets the default viewtype, which is used when opening a new 2D/3D view.
(See Visualisation of data 95)

Online preview:



Select intensity scale factor for the online preview (0..1). You can set some default values, by pressing one of

the "Set" buttons.

- **Additional - Naming convention**

  You can define some default names, that will be used when a new object is created.

- **Additional - Project manager**

  Sets several settings for the "Project window".
  (See Main menu 14)

- **Additional - Recent projects and folders**

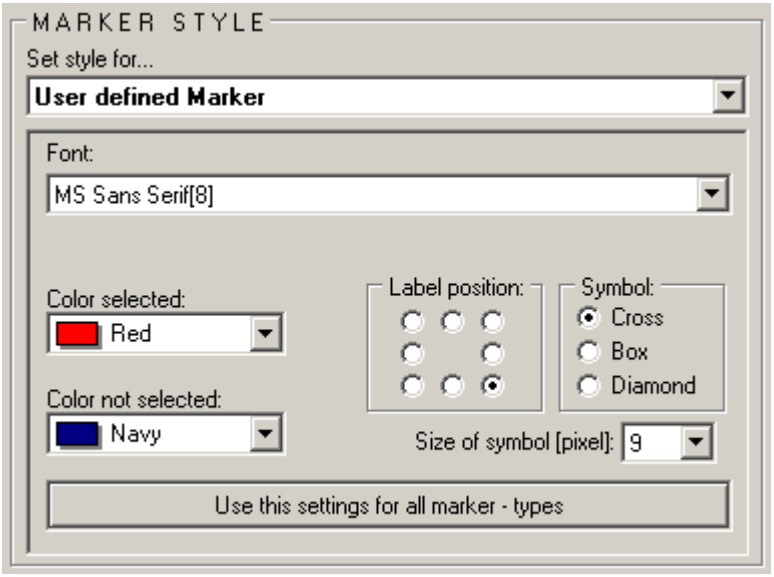
  Sets the initial project folder and shows the recent projects.

- **New project**

  Sets the default settings for a new project.

- **2D Settings - Marker settings**

  Sets the marker style(s) of the 2D - view window.

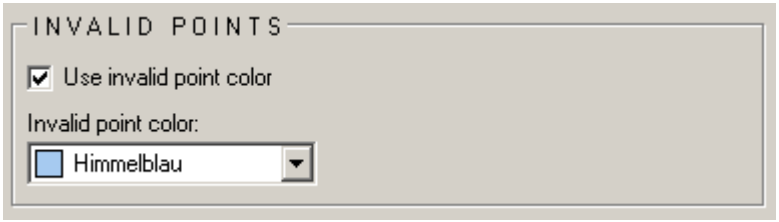


You can set the style for each tiepoint type. This is useful when e.g. TPL SOCS and TPL IMAGE are displayed in an image.

With "Label position:" you can select where the label (=name of the tiepoint) should be placed. This is useful, when two tiepoints of different type (e.g. a TP SOCS and a TP IMAGE) are at nearly the same position (Due to the fact that the labels are on different positions, you will be able to read the names of the tiepoints).

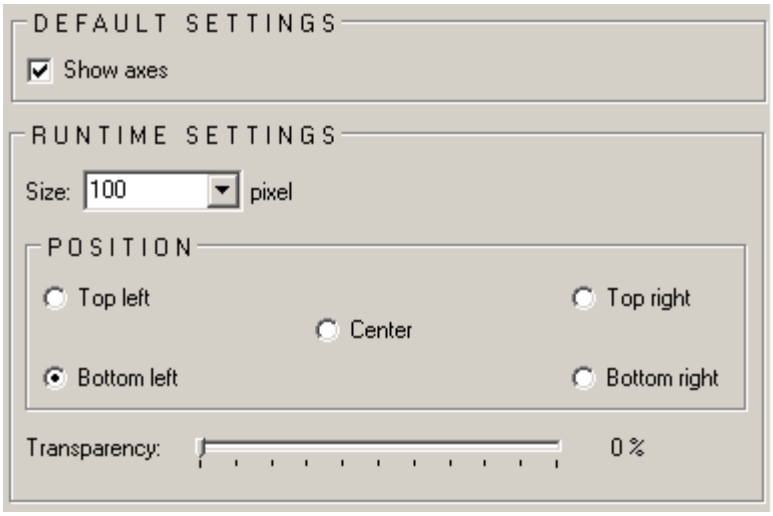
By clicking on "Use these settings for all marker - types" all marker - types will have this style. So if you display different tiepoints in a 2D-View they will all look the same.

- **2D Settings - Other settings**



Use invalid point color
Activate this option, if you want to use a defined color (*Invalid point color*) for invalid measurements in a 2D view of a scan.

- **3D Settings - Axes settings**



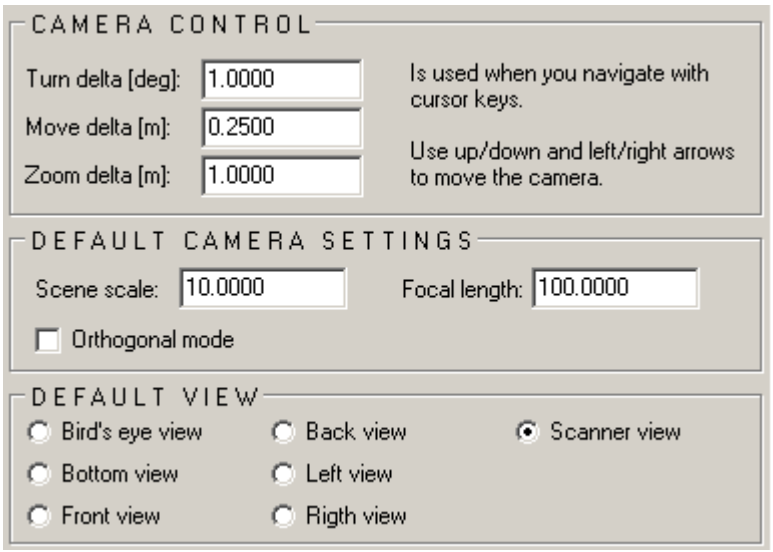
Default settings

- **Show axes**
  Activate this option, if you want to display the axes when a new object view[102] is created.

Runtime settings
This settings will influence the appearance of all object views.

- **Size**
  Define the size of the axes in pixels.
- **Position**
  Define the display position of the axes.
- **Transparency**
  Define the transparency of the axes.

- **3D Settings - Camera settings**



Camera control
You can define the values for navigating with the camera in an object view[102].

Default camera settings & Default view
These values are used when you create a new object view[102].

- **3D Settings - Color Settings**

Default color
Default colors are used when you create a new object view[102] or when you display objects.

Runtime colors

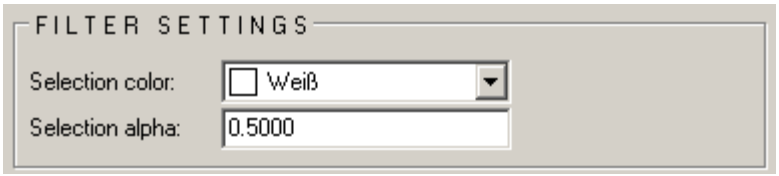
Selection color ... This color is used when drawing selections in selection mode.
Selected color ... This color is used when you have select some data.

Runtime colors influence the appearance of all object views.

- **3D Settings - Display settings**

These settings are used, when you create a new object view[102].
For detailed description of these values see the object view[102] reference.

- **3D Settings - Other settings**



Sets the default settings for a filter selection (create new orthophoto 165).

- **Object view settings - Control settings**

  Mouse
  Defines the sensitivity of the mouse.

- **Object view settings - Save settings**

  Define how an object view should be handled.
  - never save ... the object view is only temporary
  - always save ... the object view is added to the project structure
  - ask user to save ... you will be asked before closing the object view

- **Calculation parameters - Averaging / Resample**

  Set the default values for the averaging/resample-process 148 here.
  If "Always ask for parameters" is checked you'll be prompted to enter the parameter each time you start the process. Otherwise the process will start with the default values.

- **Calculation parameters - Find corresponding points**

  Sets the default settings for Finding corresponding points.
  (See Registration of a scan position 125)

3.3 Coordinate systems

RiSCAN PRO uses different coordinates systems, the most important ones are described below:

Scanner's Own Coordinate System (SOCS) is the coordinate system in which the scanner delivers the raw data. Consult the user's manual of the scanner for the definition of the coordinate system. The data of every RIEGL 3D laser imaging sensor contains for every laser measurement geometry information (Cartesian x, y, z coordinates or polar r, ϑ, φ coordinates) and additional descriptors (at least intensity, optionally color information). Thus the output of a RIEGL 3D laser imaging sensor can be addressed as a (organized) point cloud with additional vertex descriptors in the scanner's own coordinate system.

Project Coordinate System (PRCS) is a coordinate system which is defined by the user which is for example an already existing coordinate system at the scan site, e.g., a facility coordinate system. RiSCAN PRO requires that all geometry data within this project coordinate system can be represented by single precision numbers (7 significant digits). For example, if mm accuracy is required, the maximum coordinates should be less than 1 km.

Global Coordinate System (GLCS) is the coordinate system into which the project coordinate system is embedded. Usually, coordinates in the global system may contain very large numbers.

Camera Coordinate System (CMCS) is the coordinate system of the camera which is optionally mounted on top of the scanner system providing high resolution images.

In almost all applications, data acquisition is based on taking scans from different locations in order to get a complete data set of the object's surface without gaps or "scan shadows". The different scan locations are addressed as **scan positions**. When starting a new project, i.e. starting a new data acquisition campaign, you have to initialise a new scan position (by default ScanPos01) before acquiring data from the scanner. This scan position will hold all data acquired at that specific setup of the scanner.

A scan position is characterized by its own local coordinate system (SOCS), i.e. the position and orientation of the scanner within the project coordinate system. Position and orientation can generally be described by 6 parameters

(3 for position, 3 for rotation) or by a transformation matrix. RiSCAN PRO makes use of a 4 x 4 matrix (MSOP) addressed as **SOP** information (SOP for sensor's orientation and position).

$$M_{SOP} = \begin{pmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

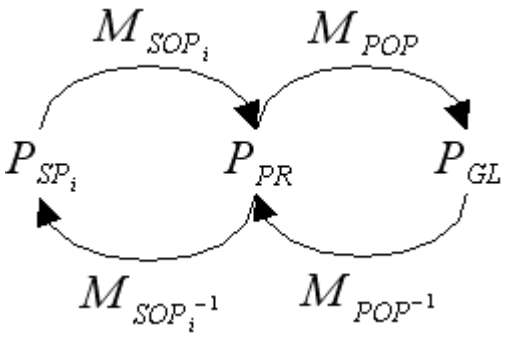
The matrix consists of 9 parameters reflecting the rotation (r11 to r33) and 3 parameters for the translation (t1 to t3). The use of homogeneous coordinates allows computation of rotation and translation in a single matrix multiplication. The translation vector is the scanners position and the column vectors (r1i r2i r3i)T are the directions of the local coordinate axes in PRCS. A 3D data point in homogeneous coordinates is represented by its 3D coordinates x, y, and z by

$$P_{hom} = (x\ y\ z\ 1)^T$$

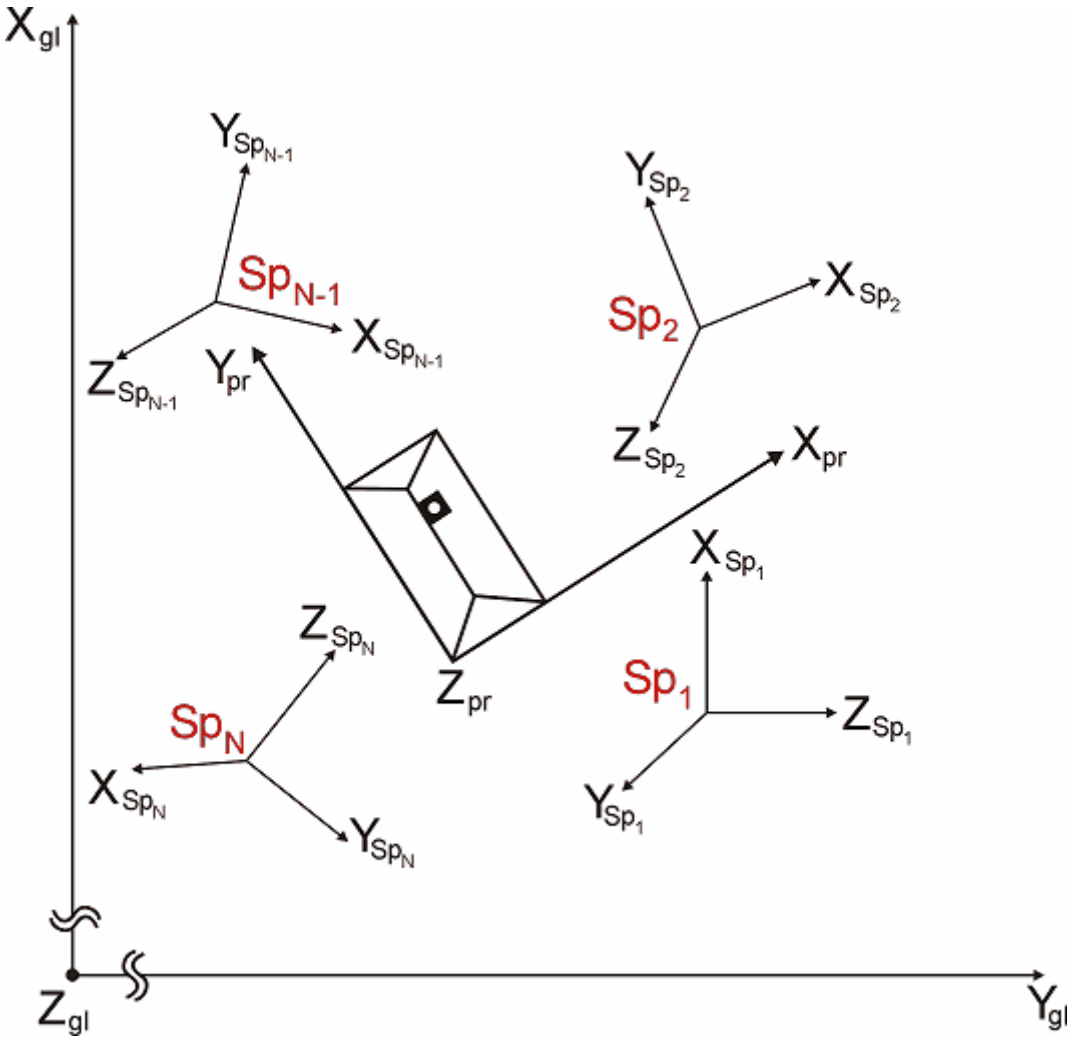
Note:
Changing the scanners orientation at a specific location requires to use a new scan position even if the scanner position has not changed.

Each scan position holds the scan data taken at this scan position, stored in the scanner's binary data format with extension **3DD**. Furthermore, each scan position holds its SOP information. In order to transform data from SOCS into the project coordinate system, data points are simply multiplied with the SOP matrix (**MSOP**) of the scan position.

In case a data point P has to be transformed from a specific scan position into the global coordinate system, multiply first with the MSOP matrix of the scan position to get into the project coordinate system and multiply subsequently with the MPOP matrix which transforms from the project coordinate system into the global coordinate system.



The sketch below shows an example for the coordinate systems GLCS, PRCS, and SOCS. The object is a building scene from a bird's view. A project coordinate system is defined with the Ypr – axis being parallel to the nave of the building and the origin of the PRCS coinciding with a corner of the building. The PRCS has to be a right-handed system. The GLCS in the example is a left-handed system, e.g, northing, easting and elevation. A number of scan positions are indicated by Spi, where the scanner has been set up for data acquisition (see the detailed description on scan positions below). Each scan position has its own local coordinate system (SOCS) resembled by the axes Xsp1, Xsp1, Zsp1.



3.4 Create new project

Generally you can create a new (empty) project by selecting Project -> New -> Project... from the menu.
You will be prompted for a filename and location of the new project.

It is recommended to use the default project 7 instead of creating a "brand-new" project.
To do so, open ("Project" ▸ "Open...") the project and save it under another filename and/or folder ("Project" ▸ "Save as...").

Using this project as a template enables you to use the existing calibrations (Camera, Mounting, Reflectors,...).
You just have to delete not needed items.

Note:
You need write permission for the target folder in order to create a new project.
The default project can not be changed because it is write protected per default.

After you have created a new project continue with the steps described in the next chapter: "Project settings 33".

3.4.1 Project settings

The next step is to set the project attributes.

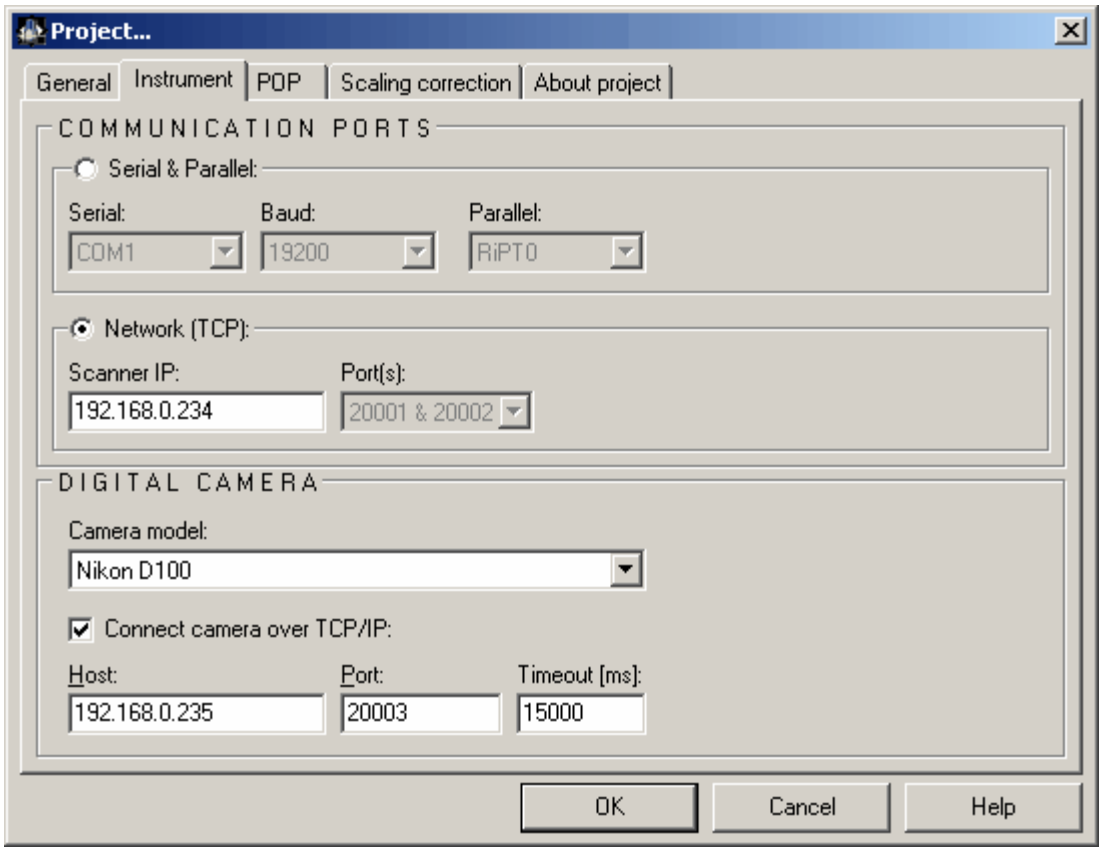
To set the project-attributes double-click on the project-name (top most entry of the Project-manager).
The dialog "Project..." appears. The dialog has following pages:

Page "General"

On this page you can insert comments like name of operator, date, location, object description and so on.

Page "Instrument"

On this page you must set the *COMMUNICATION PORTS* to enable communication with the instrument.



First select "Serial & Parallel" or "Network" to determine the basic way of communication, corresponding of the type of cabelling of your instrument.

Serial & Parallel:

When "Serial & Parallel" is selected you have to select the serial port (COMx), baud rate (default is 19200) and the parallel port (RiPTx) according to the settings of RiPORT 205.

Network (TCP):

When "Network (TCP)" is selected you have to enter the correct IP address of the device (192.168.0.234 per default). The ports can not be modified and are only displayed for your information. If you don't know the IP address of the instrument you can also use the tool "Scanner Search 14".

Note:
If you have problems while connecting to the instrument, please make sure that you have used the correct cables. If you use a firewall please make sure that bidirectional communication over the ports displayed on this page is allowed.

Note:
Please make sure that your PC has a valid IP address. To do so check the TCP/IP settings of the network connection. If "obtain IP address automatically" is selected it is necessary that a DHCP server is installed in your network. If no such server is installed (and of course when you connect the instrument directly to the PC via a cross over cable) you have to set a fixed IP address in the same logical network IP address range as the instrument (e.g. 192.168.0.233) and a proper subnet mask (e.g. 255.255.255.0).

Please refer to the help file of MS Windows or contact your network administrator.

On this sheet you can also set the camera type in case your instrument is equipped with a camera.
If you notice problems when connecting to your camera directly through RiSCAN PRO, please check the "USB-protocol" setting of the camera. This value must be set to "PTP" for NIKON cameras and to "normal" for CANON cameras. For changing this setting please refer to the product documentation of your camera.
Select "Connect camera over TCP/IP" if the camera should be accessed via the network by using the camera server (default value of Port: 20003).

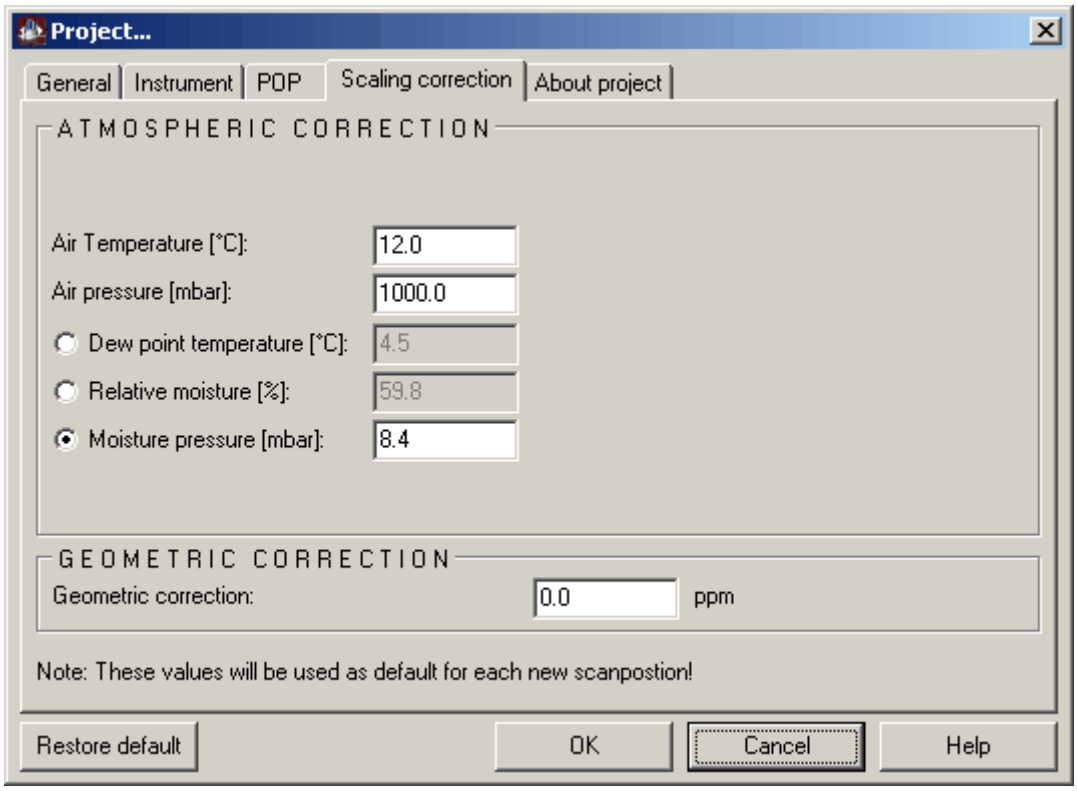
Page "POP"

This page displayes the POP matrix (see "Coordinate systems 30").

Page "Scaling correction"

To achieve maximum accuracy for the range measurement, set the atmospheric values to the actual values during data acquisition. The *GEOMETRIC CORRECTION* can be entered by the user and is applied to the measurements (ppm = parts per million).

Note: The values entered here will be the default settings for each new scan position.



Page "About project"

This page offers information about the project files such as location, number of files and total size of the project.

3.4.2 Create new scanposition

To create a new scan position just click with the right mouse button on the folder "SCANS" and select "New scan position". A dialog as shown in the section below is displayed which allows you to set the attributes of the scan position. The name of the new scan position will be set to "ScanPosXX", where "XX" is an unique number. You can rename the scan position and give it a more meaningful name. To finally create the scan position click on the button "OK".

scan position attributes

To modify the attributes of a scan position click with the right mouse button on the scan position and select "Attributes...". A dialog appears showing the following pages:

Page "General"

Enter comments or a basic description here.

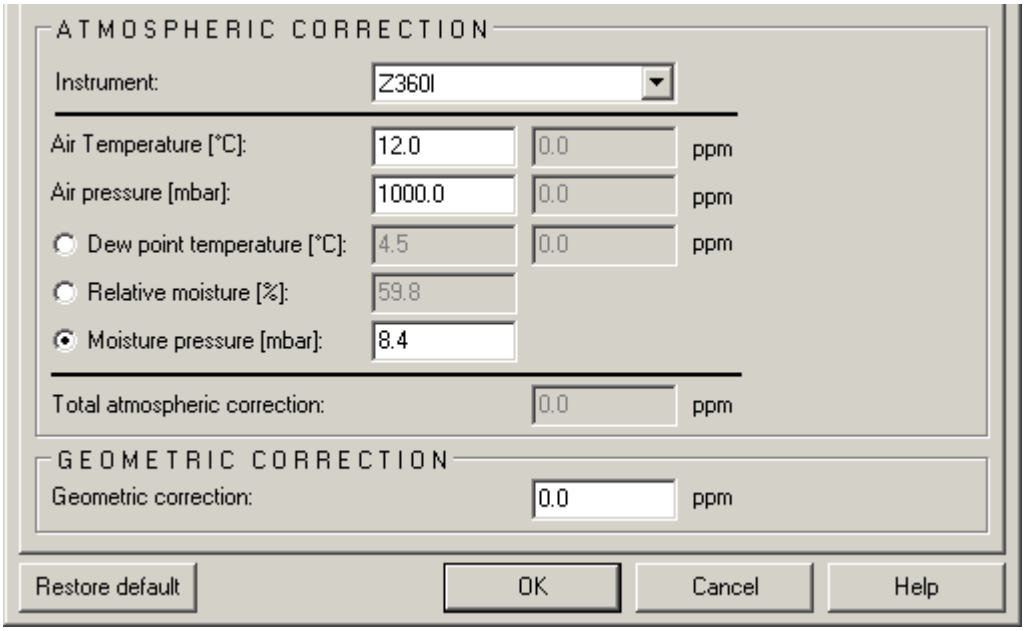
Page "Tilt mount"

see "Calibrations: Tiltmount 59"

Page "SOP"

This matrix will be used to align the scan position within the project coordinate system (see "Coordinate systems 30").

Page "Scaling correction"



Choose an instrument from the list and adapt the values for the *ATMOSPHERIC CORRECTION* to ensure exact measurements.
Note: These values are initialized with the project settings (see "Project settings 33").

3.5 Calibrations

3.5.1 Camera

In order to make use of the image data acquired within RiSCAN PRO you need calibration data of the camera used. These calibration data include data on the camera itself, e.g., dimensions of the images in pixels, the focal length of the lens, and the center of the camera image. Furthermore, you need information about the position and orientation of the camera for every image to, e.g., apply the color of a pixel to a 3D surface. RiSCAN PRO provides the orientation and position information "automatically" in case the camera is mounted on top of the scanner. Up to this point the parameters describe an ideal "pin-hole" camera. However, in practice the lens introduces significant distortion. This lens distortion is modelled within RiSCAN PRO by up to 6 parameters. For more details see Camera model used 37.

The camera, when ordered with the scanner, is delivered with calibration information. This information is gained by using the calibration procedure integrated in RiSCAN PRO (usually Based on reflector column 42).

But please note the following:

The internal camera calibration parameters depend on
- the lens itself (even the same type of lens will lead to a different set of parameters)
- the setting of the focus
- the setting of the aperture.

Thus it is recommended to fix the camera's focus and aperture BEFORE doing the calibration. Setting the focus depends on the intended distance the camera will be used. Please note that you always have a finite depth of the focus which is larger the higher the aperture number is chosen.

When we tolerate blurring of 0.25 pixels we can set the focus to

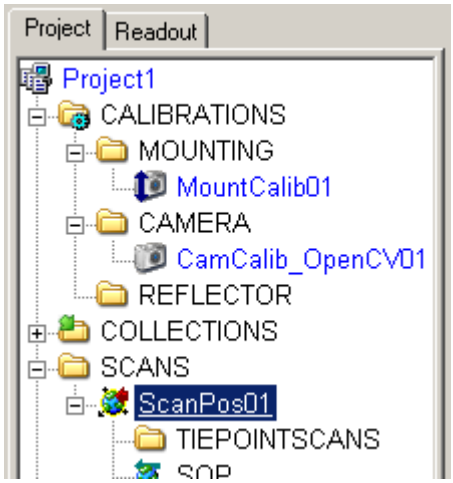
$b = 4f^2/(dx\ a)$

where f is the focal length of the lens in meters, dx is the pixel size in meters and a is the aperture number of the lens. In this case we get "unblured" images in the range from b/2 to infinity. For example, dx = 7.8 µm, f = 14 mm, a = 9 gives b = 11 m and an operational range from 5.5 m to infinity.

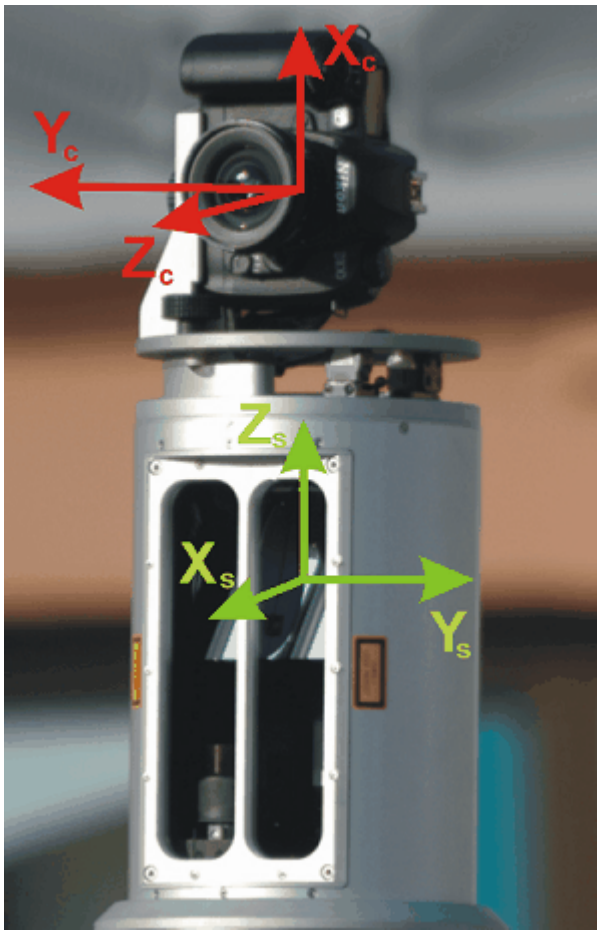
The external camera calibration parameters, especially the orientation of the camera when mounted on top of the scanner, will be changed after detaching and mounting. To account for these changes please refer to mounting calibrations.

3.5.1.1 Camera model

RiSCAN PRO uses a camera model similar to the one used in the "Open Source Computer Vision Library" maintained by Intel (see http://www.intel.com/research/mrl/research/opencv/ for details).
The calibration parameters defining the camera model (intrinsic and internal parameters) are stored within RiSCAN PRO in a tree node called CamCalib_OpenCV01 by default. A complete camera model usually includes also external calibrations parameters defining the orientation and position of the camera in 3D space. This information is held in RiSCAN PRO in the mounting calibration matrix, the COP matrix associated with each image at a scan position and the SOP information of the scan position.



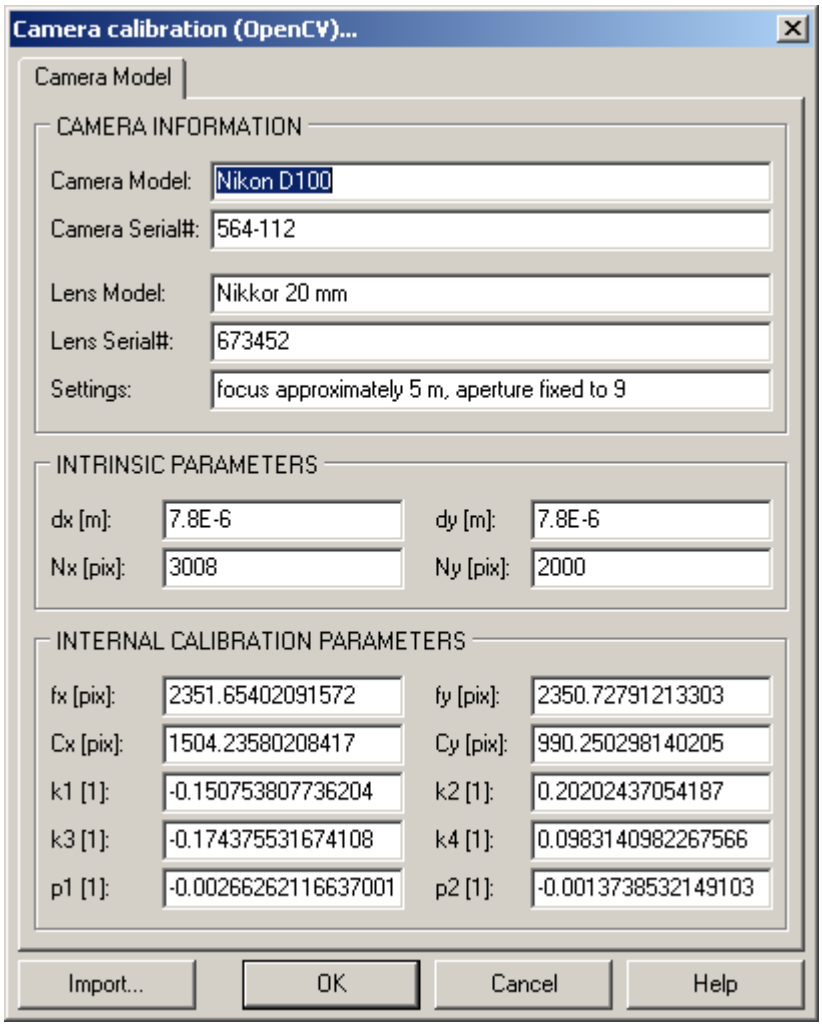
The camera model is based on a camera coordinate system (addressed within RiSCAN PRO as CMCS). The image below shows the Nikon D100 mounted on top of a LMS-Z360 with the axes of the SOCS and CMCS. The origin of the CMCS is the center of an equivalent pinhole camera. CMCS is a right-handed system with the x axis pointing from left to right in the image and the y axis from top to bottom. The z axis is identical to the center of the field of view of the camera.



The camera model is described by 4 intrinsic parameters and 8 internal calibration parameters. Additionally, descriptive information can be stored within RiSCAN PRO for documentation and data management in the field camera information.

Camera information is not used for any computation but as the internal calibration parameters are unique for every combination of camera specimen and lens specimen you should always make extensive use of the descriptive text.

Intrinsic parameters reflect basic parameters of the camera chip (CCD chip). Nx and Ny are simply the number of pixels in the horizontal direction (x direction) and the vertical direction (y direction), respectively. The parameters dx and dy are the dimensions of a single pixel of the CCD sensor. This parameter is commonly specified by the manufacturer, for the Nikon D100 the pixel size is 7.8 µm.



Internal calibration parameters can be divided into parameters describing (more or less) an ideal camera, i.e., a so-called pinhole camera. This is the focal length and the center of projection (the orthogonal projection of the pin-hole onto the chip surface). Two potentially different focal lengths (fx and fy) are used to account for the potentially different pixel size in x and y direction and to account for different focal length's of the lens (cylindrical lens error). The parameters fx and fy are normalized by the pixel size. The physical focal length is fx * dx. In the example above, fx * dx is 18.3 mm, pretty close to the nominal 20 mm of the lens. The center of the image is (Cx, Cy) in pixels. Usually, i.e., for low distortion lenses Cx ~ Nx/2 and Cy ~ Ny/2. Deviations account for a decentered lens and/or chip.

$$f_x = \frac{f}{d_x}$$

fx.....[pix]
f.....focal length [m]
dx.....[m]

Lens distortion is modelled by at least two radial and two tangential coefficients, k1, k2, p1, p2, respectively. In case k3 and k4 are both 0, the camera model is identical to the one described in OpenCV. The parameters k3 and k4 account for higher-order modelling of the radial distortion. The details on how the parameters are applied to transform from undistorted coordinates (i.e., ideal pinhole camera) to distorted coordinates are contained in the

appendix describing the XML project file.

3.5.1.2 Camera calibration

Prerequisite for calibrating a camera is one or more images showing identifiable objects with precisely known coordinates.
The first step to obtain a data set for calculating the model parameters is to

- determine the image coordinates of the object, i.e. find the image points, and to
- link the objects to the image points, i.e., to find the correspondences.

There are three different approaches that differ in the way the object coordinates in 3D are obtained and the way the correspondences are determined. All approaches are implemented in RiSCAN PRO and are described subsequently.

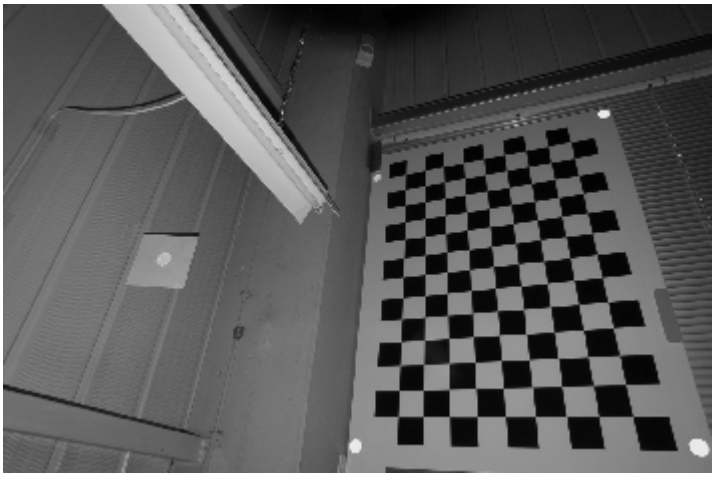
Based on reflector column

The basic idea is to set up a test field made up of a number of retroreflective targets positioned in a vertical column in a scene when viewed by the camera. The targets should (1) cover the vertical field of view of the camera and (2) should have a variation in depth. it is not required that the calibration field is long-term stable. The camera to be calibrated is mounted on top of the scanner and the test field is surveyed by the laser scanner by carrying out a number of tiepoint scans on the automatically detected targets. Then, a series of images with flash is taken at different angular positions of the camera (automatically carried out by the calibration task). In every image the centers of the reflectors are extracted automatically and the extracted reflectors are linked automatically to the 3D coordinates of the targets. By this procedure, a virtual test field is generated covering in total the complete field of view of the camera.

The major advantage is that the test field can be put up easily, no total station is required, and the calibration task gives both the internal camera calibration parameters and the mounting calibration parameter.

Calibration based on flat check pattern images

Especially for wide-angle lenses (for the Nikon D100 up to about 40 mm) calibration based on flat check pattern images has been found useful. One example of an image is shown below, which shows a flat check pattern printed on white paper used to calibrate the camera with a 14 mm lens. The size of one square is 0.1 x 0.1 m. The check pattern is glued to a plane board to ensure the pattern is really flat.



For the calibration the flat check pattern is captured by the camera to be calibrated several times. The whole image area should be covered in total, and in each image the complete pattern has to be visible. The inner check pattern corners are detected automatically by the calibration software and are automatically linked to the 3D coordinates of the flat check pattern corners (z is always 0).

The calibration software calculates best estimates for the 10 internal parameters and for the 6 external parameters of each image in order to minimize the deviation. The output of the calibration procedure is stored in a CamCalib_OpenCV node within the project for further use.

With every instrument a calibration file is delivered for the camera being part of the instrument. Thus, it is not necessary to recalibrate the camera as long as the lens parameters (focus, aperture, or specimen) are not changed.

Calibration based on reflector array

Especially for telephoto lenses, the calibration approach based on imaging flat check patterns is inconvenient as for a fixed focus of infinity the minimum range to the pattern has to be quite large and thus the dimensions of the flat check pattern has to be large too. This second approach is based on imaging a field of reflectors of known coordinates in 3D, addressed as reflector array subsequently. The reflectors must not lie in a single plane, but have to be distributed in a volume with sufficient depth. In the example below the reflectors have been fixed to a building to both sides of one corner and also to the roof. The reflector positions have been surveyed by means of a total station with mm accuracy.

Assign camera calibration to images

The camera calibration can be either assigned to each image on by one (image attributes 74) or you can assign the camera calibration to a couple of images at one step. To do so, please click with the right mouse button on the camera calibration and select "Assign to images..." from the menu. In this dialog you can define several filter settings. At the bottom of the dialog you'll see a summary of the filter settings explaining which images will be modified in fact.

3.5.1.2.1 Base camera calibration

To start with a new camera calibration task based on reflector column 42 you need an initial camera calibration. You can either use the camera calibration of an other camera of the same type and lens or you can use the new camera calibration wizard. This wizard allows to create an initial camera calibration based on the information provided by the user such as camera type and type of lens. The created camera calibration doesn't contain distortion parameters, of course.

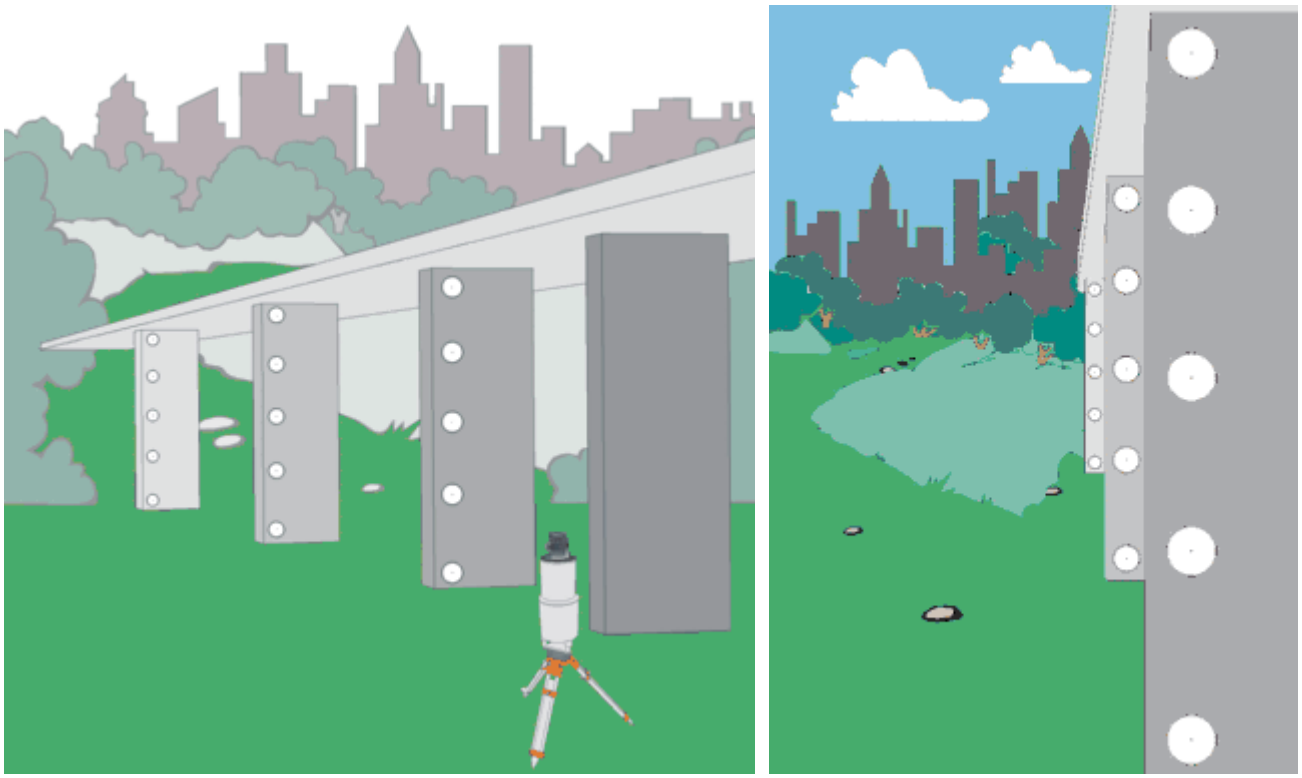
To use the wizard please proceed as follows:

- Open or create a project.
- Click with the right mouse button on the folder "CALIBRATIONS / CAMERA" within the project manager.
- Select "New camera calibration (wizard)..." from the menu.
- **Step 1:** Define camera model
  At this step you can either select your camera type from the list or you have to enter the camera parameters on your own. The parameters you have to enter are the camera model (just for your own information) the number of pixels and the size of one pixel of the image chip in both directions (vertical and horizontal).
- **Step 2:** Define lens model
  At this step you can either select your lens model from the list or you have to enter the lens parameters on your own. The parameters you have to enter are the lens model (just for your own information) and the focus in millimeter.
- **Step 3:** Define additional data
  At this step you can enter additional information such as camera settings and serial numbers of camera and lens. Although it's not necessary to enter values at this step it is strongly recommended to do so. This makes it easer to keep an overview which camera calibration belongs to which camera and lens.
  Finally enter a name for the new camera calibration and click on the button "OK" to create it.

3.5.1.2.2 Based on reflector column

This task allows the user either to check the camera calibration or to execute the camera calibration by means of an easy to set up calibration field.

The basic idea is to have a number of retroreflective targets positioned in a vertical column in a scene. The images below show an example of how the reflectors may be applied to existing structures, e.g., the supports of a bridge. The targets should (1) cover the vertical field of view of the camera and (2) should have a variation in depth, i.e., the targets should not be placed on a single plane normal to the principle axis of the camera. On the right image the camera images is shown with the reflectors covering a vertical band of the field of view.



The image below shows an indoor scene with 9 reflectors attached to a column in about 3 m distance, 7 reflectors at a distance of about 8 m, and one reflector at a distance of about 13 m. The image is taken with a flash so the targets show up clearly in the image.

This calibration field alone is insufficient for accurately determining the calibration parameters of the camera. But as the camera is mounted on the rotating part of the scanner, a sequence of images can be recorded and all extracted targets of all images cover the complete field of view of the camera and give thus a very good calibration field.

Usually a calibration field is surveyed by means of a total station. As the laser scanner can provide the position of the targets in its own coordinate system very accurately by means of doing fine scans (tiepoint scans) no total station is required. By arranging the targets as described above only few targets have been measured (in the example above 17 targets). By taking 20 images and extracting the reflectors each provides a virtual test field with about 340 targets.

So after setting up the test field by placing a number of targets as described above, the scanner with the camera mounted on top is set up in front of the test field.

The procedure to extract the calibration data based on a reflector column using the scanner and the camera mounted on the scanner is:

Creating the new camera-calibration-task

1. Generate a new camera-calibration-task in an existing project or make a new project first. To do so right-click on the CAMERA node and choose **New calibration (reflector column) …** from the menu.

2. You are prompted to select an initial camera-calibration and a initial mounting-calibration. You can either select a calibration from the list or import it from an other project (i.e. the default project - if copied during the setup of RiSCAN PRO). If you have no matching camera calibration you can also use the new camera calibration wizard 42. These calibrations are used for initializing the task. The better these

calibrations are the easier the data-acquisition and thus the whole calibration task will be.

3. You are also prompted to select a scan position where the scan, the finescans and the images should be saved. Click on "create new" to create a new scan position.

4. Confirm the dialog by pressing on the button "OK".

5. A small wizard will appear on the top right corner of RiSCAN PRO. This wizard will guide you through the steps of the data acquisition needed for the camera-calibration-task (Once you have closed the wizard you can re-start it by right-clicking on the camera-calibration-task and selecting "Acquire calibration data..." from the menu).

Calibration data acquisition step by step (with the wizard):

1. Acquire new single scan

The first step is to acquire a scan of your calibration field. This scan should contain all reflectors of your calibration field. Click on the button "Start", configure the scan as usual 65 and start the scan.

2. Reflector extraction

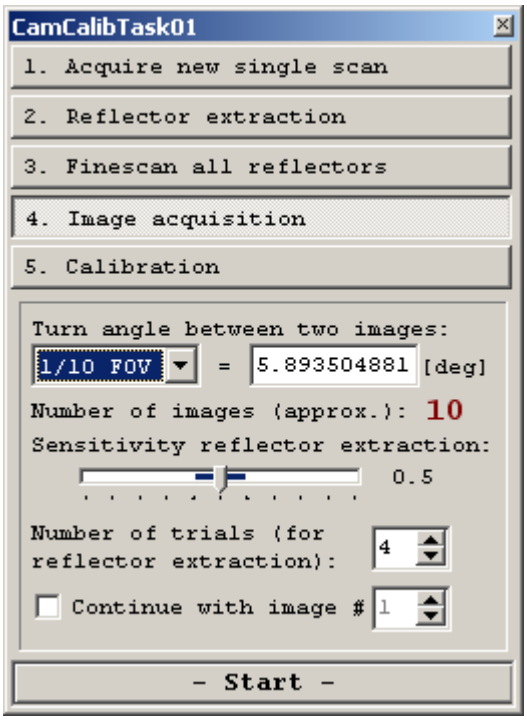
The second step is to extract the reflectors of the scan made at step 1. Select the scan from the list (should be already pre-selected) and click on the button "Start".
Configure the reflector extraction as usual 73. The TPL SOCS of the scan position will be displayed showing all reflectors extracted. Please open the scan and display the TPL SOCS in order to check if all reflectors where extracted and delete all reflectors not needed (faulty detection or wrong targets).

3. Finescan all reflectors

The third step is to make tiepoint scans 90 of all reflectors extracted at step 2. By clicking on the button "Start" all reflectors of the TPL SOCS will be fine scanned.

4. Image acquisition

The fourth step is to acquire images containing all reflectors. The first image will be acquired in order to have the reflectors in the center of the image. Before taking the second image, the scanner will turn to the next position (see "Turn angle between two images 42"). The image aqcuisition will be continued this way until no reflector can be extracted from the image. Configure the image acqusition (see "Description of the input fields 42" for more details) and start the image acquistion by clicking on the button "Start".



Description of the input fields:

- Turn angle between two images
  Images will be taken in that angular distance. Either select one entry of the list on the left side or enter the angle on the right side. The list contains some default values expressed as fraction of the vertical field of view (FOV) of the camera (default is 1/10 FOV).

- Number of images (approx.)
  This shows the approximate number of images which will be taken (Note, that this value depends on the quality of the initial camera- and mounting-calibration and may differ from the actually taken images).

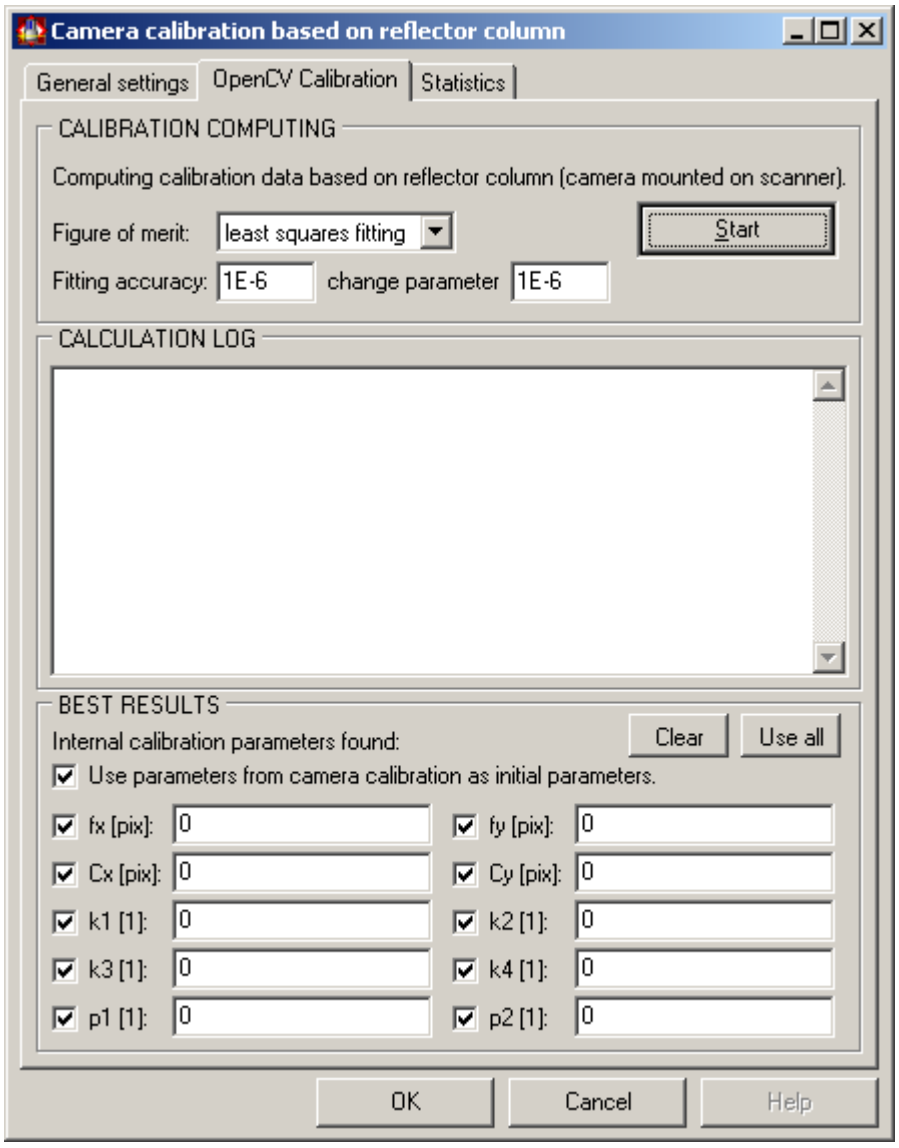
- Sensitivity reflector extraction
  With this slider you can set the sensitivity for the reflector extraction (of the images). The Range is 0 up to 1, default is 0.5. If the images are very bright try to raise this value and vice versa.

- Number of trials (for reflector extraction)
  The algorithm will try "Number of trials"-times to extract one single reflector of the image until it fails (default is 4).

- Continue with image #
  If you start the image acquisition the first time you can leave this setting as it is. If the image acquisition was interrupted (because i.e. something got wrong during the reflector extraction, power-loss of the camera or the reflectors where covered by something else) you can restart it by clicking on the checkbox and selecting the number of the image which should be the next image acquired.

5. Calibration

After the image acquisition has finished you can calibrate the camera. To do so click on the button "Start". The following dialog will appear:



On this page you can select which calculation method (*least squares fitting or robust*) should be used ("Figure of merit"). We recommend to use the default "robust" fitting which minimizes the sum of the absolute values.

The parameter "Fitting accuracy" defines the change in the residual error which stops the iterative optimization process. The default value is 1E-6. Values should range between 1E-4 and 1E-8.

The parameter "Change parameter" defines the absolute change of the ten calibration parameters. The default value is 1E-6. Values should range between 1E-4 and 1E-8.

Additionally you can select which of the parameters should be optimized. Select or deselect the parameter by means of the checkbox to the left of the parameter. The usage of K3 and K4 may improve the accuracy of the calibration, especially for wide angle lenses.

The button "Clear" will reset the parameters and uncheck all parameters. The button "Use all" will check all parameters (all will be used for the calibration.

If you select "Use parameters from camera calibration as initial parameters" the parameters are

initialized with the parameters from the initial camera-calibration (Use this the first time you start the calibration).

Finally start the calibration by clicking on the button "Start". The calibration will by started and you can watch the progress in the "CALCULATION LOG". After the calibration has finished you can switch to the third page "Statistics". On this page you will see a table showing all images and their mean, minimal and maximal pixel-distances (between tiepoints of the image and the tiepoints of the scan). At the current state an average pixel-distance about 0.5 can be considered as a good result.

To use the results in another project just import the camera- and mounting-calibration by right-clicking on "CALIBRATIONS" and selecting "New OpenCV..." (to import a mounting: "New mounting...") from the menu. On the following dialog click on the button "Import" to import the calibration.

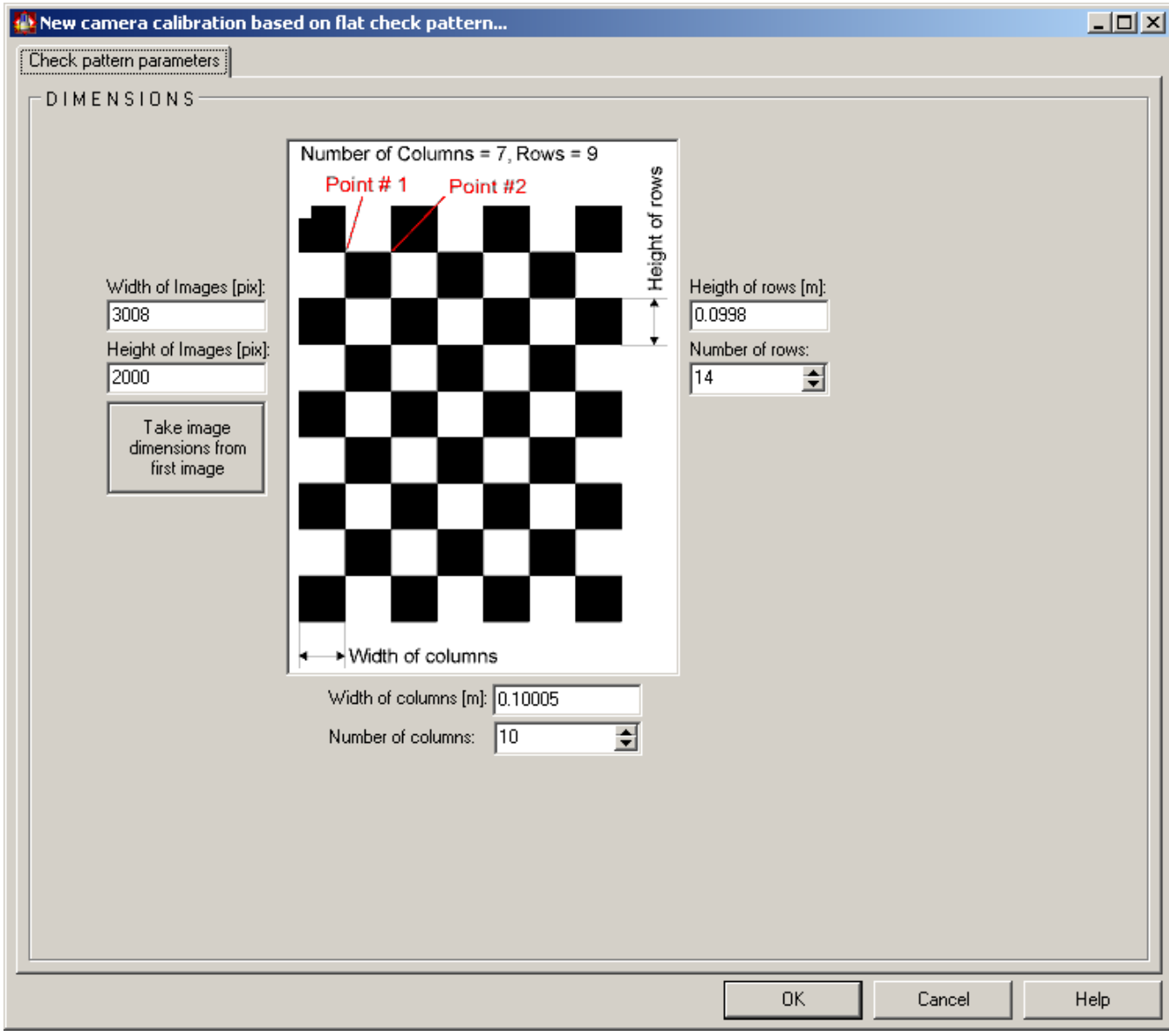
Hints:
Problems during camera calibration may be based on faulty assigned camera- / mounting calibrations. Please make sure that the correct camera- and mounting calibration is assigned to all images. Always assign the resulting calibrations located within the calibration taskk!

3.5.1.2.3 Based on flat check pattern

To do the calibration on your own you need a check pattern. The pattern has to be as flat as possible and as regular as possible with a high contrast. In the help directory you find a pdf file (CheckboardScaled.pdf) showing a check pattern of 11 columns and 15 rows.

The procedure to extract the calibration data based on a flat check pattern is:

1. Generate a new node CamCalibTask in an existing project or make a new project first. To do so right-click on the CAMERA node and choose **New calibration (flat check pattern) …** from the menu. The following dialog will appear:



To initialize the camera calibration task set the values on the first page:

DIMENSIONS

- *Width and Height of Images in pixel*

  here you can either enter the dimensions of the images directly or you can click on "Take image dimensions from first image" *after* importing the images of the check pattern (see step 2).

- *Height of rows*

  the height of one row of the check pattern in meters.

- *Number of rows*

  the number of rows of the check pattern .

- *Width of columns*

  width of one column of the check pattern in meters.

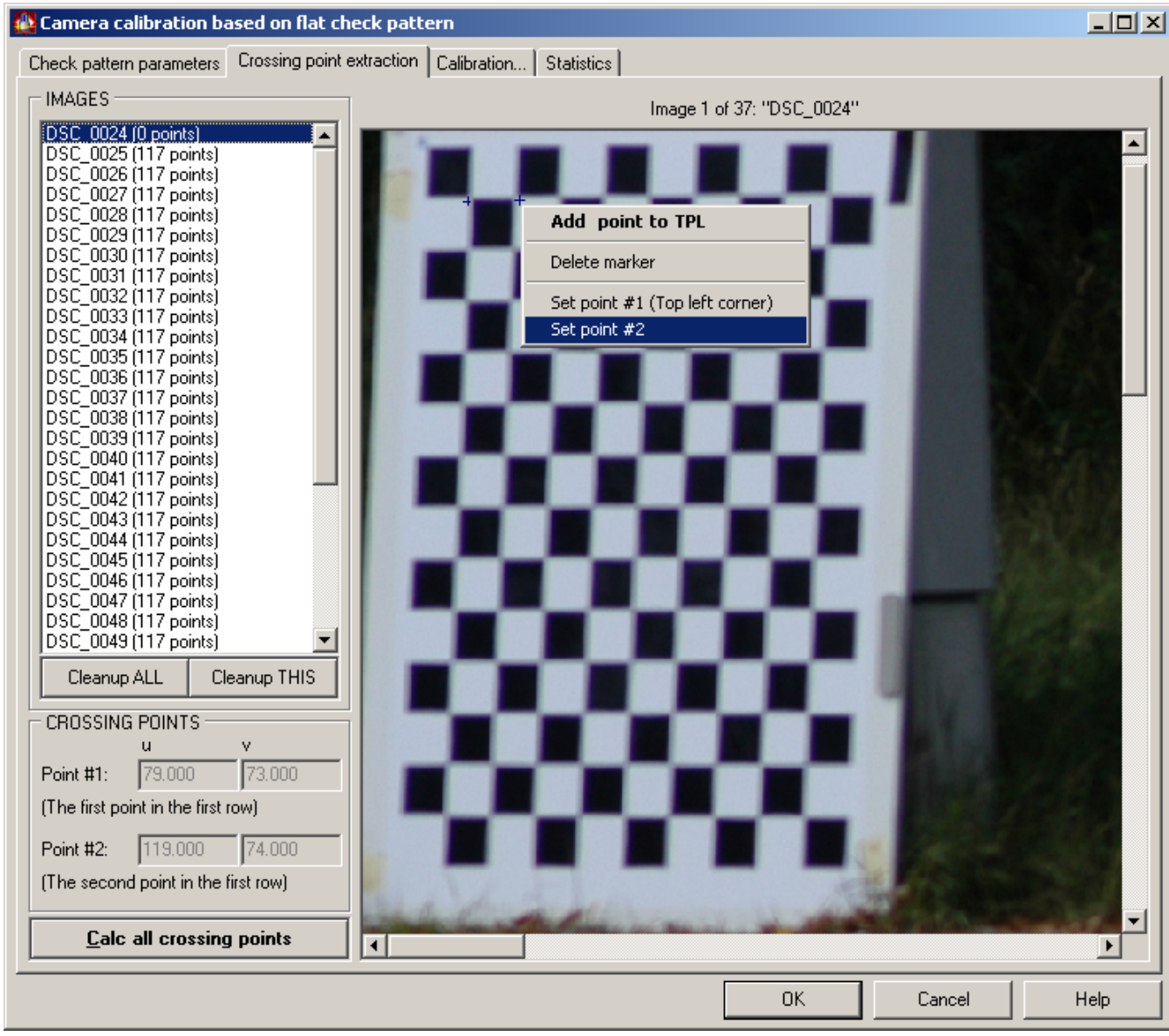
- *Number of columns*

  the number of columns of the check pattern.

Confirm with OK. The new node is named CamCalibTask01 (the number will be increased due to existing tasks) by default.

2. Right-click on the node CamCalibTask01 and select **Add image(s) …**. Add all images taken with the camera to be calibrated showing the flat check pattern from different view angles (take more images by tilting and panning the camera while taking shots).

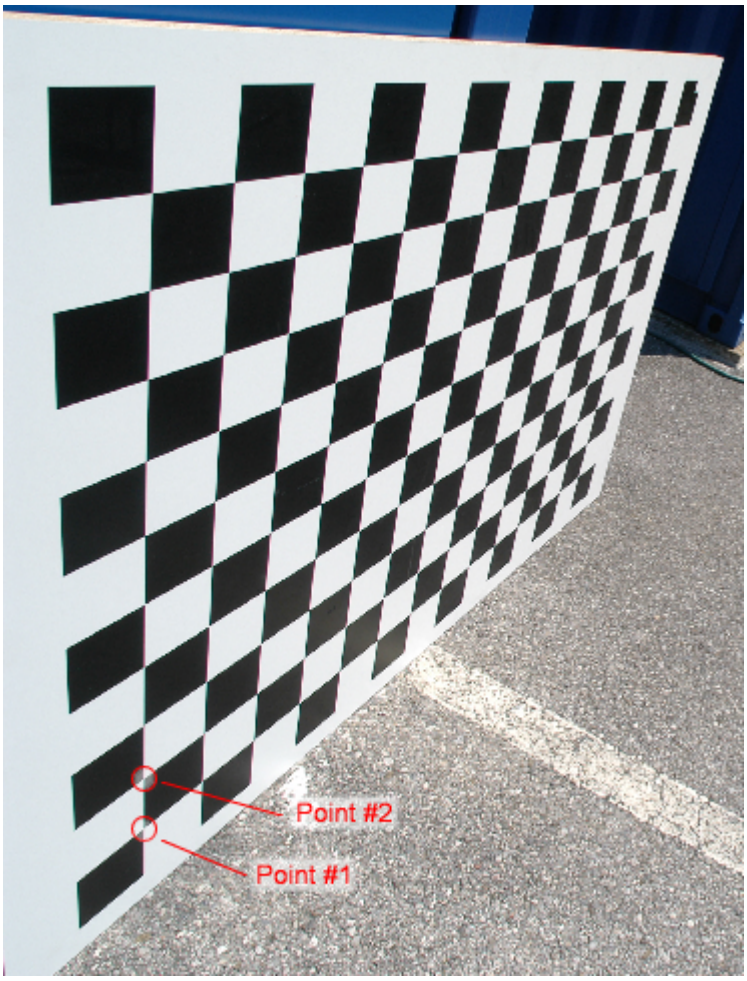
3. The next step is to extract all crossing points (corner points of two neighbouring black fields) of the check pattern in all images.
   Open the CamCalibTask01 (double click, or right click and select "Attributes").



Select an image of the image list on the left side. This will load the image into the window on the right side.
Now set two markers at the first two crossings in the first row by single-clicking with the left mouse button (like the image above shows). Now you have to identify the points through a single right-click on each marker and selecting its position from the menu (the order is not important). If you have done a faulty assignment you can simply overwrite it by doing the assignment a second time.
The button "Calc all crossing points" will cause RiSCAN PRO to calculate all other crossing points, which will take, dependent on your computer configuration, more or less time. The result of the calculation will be displayed in the image by markers.

Distorted check pattern

In some cases automated detection of corner points fails. Especially when perspective distortion yields a ratio in width and height of the first square significantly different from 1 (compare the subsequent image). In this case try to define the opposite square as the first square. Use again the clockwise orientation.

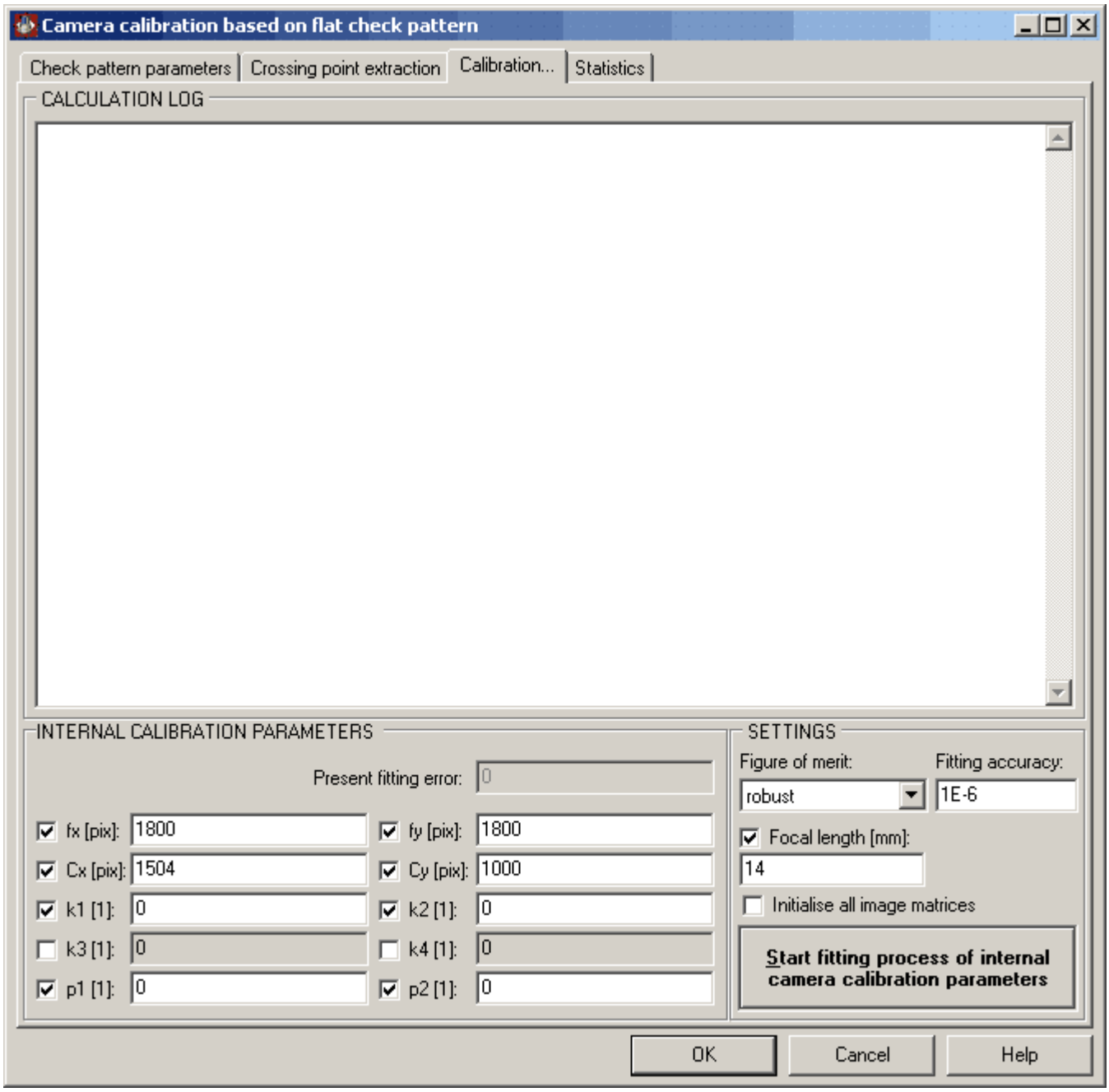


Example for an extremely distorted check pattern

Process all images sequentially in this way.

The buttons "Cleanup ALL" and "Cleanup THIS" will delete the found crossing points of all images or of the current image.

4. Now proceed by switching to the page "Calibration...". On this page you can select which calculation method (*least squares fitting or robust*) shell be used ("Figure of merit"). We recommend to use the default "robust" fitting which minimizes the sum of the absolute values.



Additionally you can select which of the parameters shell be optimized. Select or deselect the parameter by means of the checkbox to the left of the parameter. The usage of K3 and K4 may improve the accuracy of the calibration, especially for wide angle lenses.

The parameter "Fitting accuracy" defines the change in the residual error which stops the iterative optimization process. The default value is 1E-6. Values should range between 1E-4 and 1E-8.

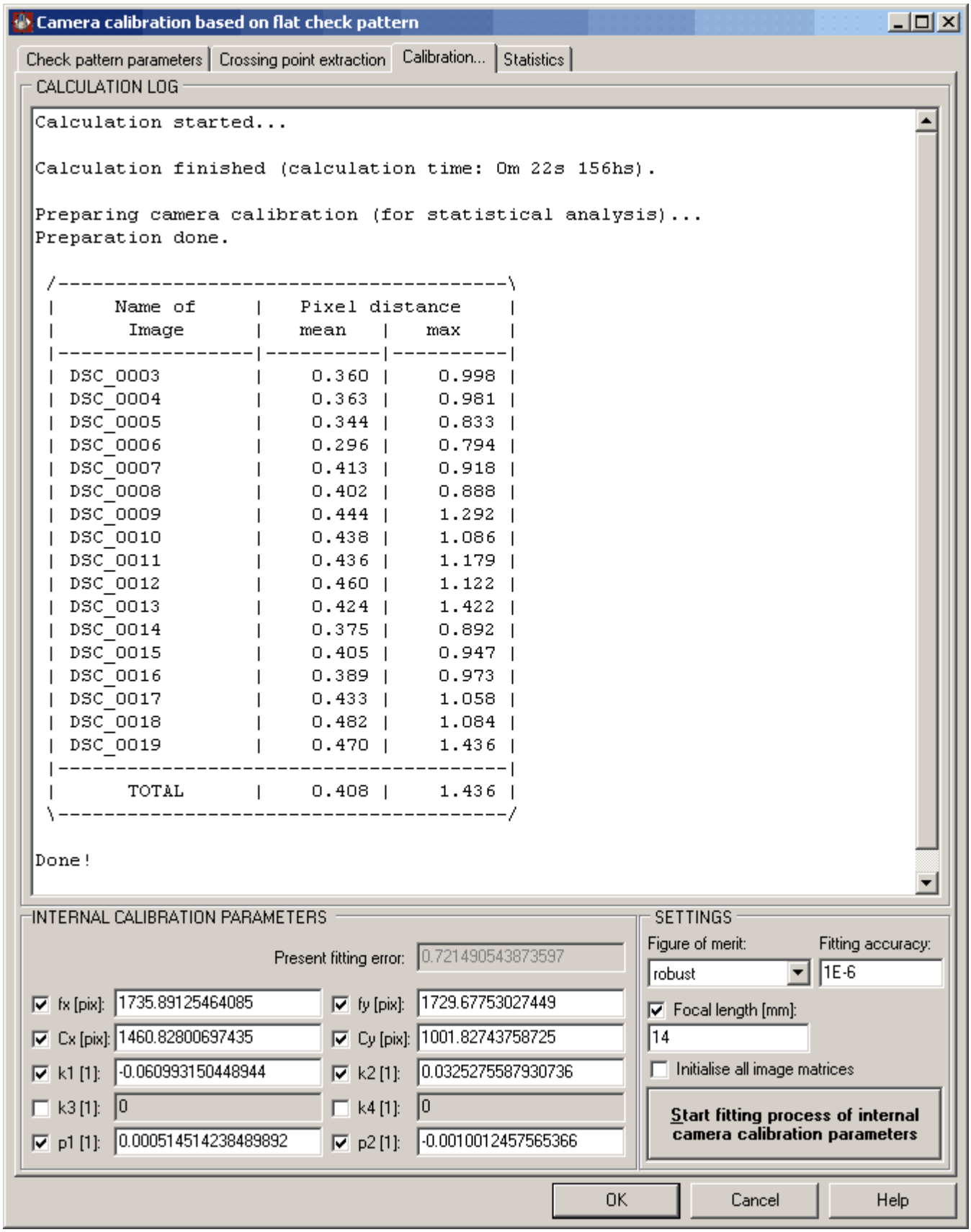
The parameter "Focal length [mm]" helps to speed up the optimization process in case the focal length is known.

The checkbox "Initialise all image matrices" re-calculates the position and orientation of the camera for every image with respect to the check pattern every time you start a new fitting process. In case you

have already run the fitting process once successfully and just want to see the impact of an additional parameter, e.g., k3, on the error, de-select this option and also deselect the "Focal length" option.

Start the fitting process by clicking on the button in the lower right corner. You can watch the progress by taking a look on the "Present fitting error".

After the calculation has been completed successfully, RiSCAN PRO displays a statistics section in the calculation log. The statistics contains the maximum and mean distances of the real crossing points (as specified by the check pattern parameters) transformed by means of the camera calibration data into image coordinates.


Camera calibration based on flat check pattern
Check pattern parameters
Crossing point extraction
Calibration...
Statistics
CALCULATION LOG
Calculation started...
Calculation finished (calculation time: 0m 22s 156hs).
Preparing camera calibration (for statistical analysis)...
Preparation done.
Name of Image	Pixel distance mean	max
DSC_0003	0.360	0.998
DSC_0004	0.363	0.981
DSC_0005	0.344	0.833
DSC_0006	0.296	0.794
DSC_0007	0.413	0.918
DSC_0008	0.402	0.888
DSC_0009	0.444	1.292
DSC_0010	0.438	1.086
DSC_0011	0.436	1.179
DSC_0012	0.460	1.122
DSC_0013	0.424	1.422
DSC_0014	0.375	0.892
DSC_0015	0.405	0.947
DSC_0016	0.389	0.973
DSC_0017	0.433	1.058
DSC_0018	0.482	1.084
DSC_0019	0.470	1.436
TOTAL	0.408	1.436
Done!
INTERNAL CALIBRATION PARAMETERS
Present fitting error: 0.721490543873597
fx [pix]: 1735.89125464085
fy [pix]: 1729.67753027449
Cx [pix]: 1460.82800697435
Cy [pix]: 1001.82743758725
k1 [1]: -0.060993150448944
k2 [1]: 0.0325275587930736
k3 [1]: 0
k4 [1]: 0
p1 [1]: 0.000514514238489892
p2 [1]: -0.0010012457565366
SETTINGS
Figure of merit:
robust
Fitting accuracy:
1E-6
Focal length [mm]:
14
Initialise all image matrices
Start fitting process of internal camera calibration parameters
OK
Cancel
Help

Furthermore, there is an additional page named "Statistics". This page shows charts representing the pixel distances of the transformed 3D crossing points to the 2D crossing points in different ways to reveal dependencies on the radial distance (uncorrected radial distortion) or the angular dependence (uncorrected translational distortion) or the crossing index number to reveal incorrect 3D coordinates due to an imperfect check pattern.

5. Copy the **Result_CamCalib** for further use to the node CAMERA by right clicking on the camera calibration task and selecting "Copy Result...".

3.5.1.2.4 Based on reflector array

The procedure to extract the calibration data based on a reflector array is:

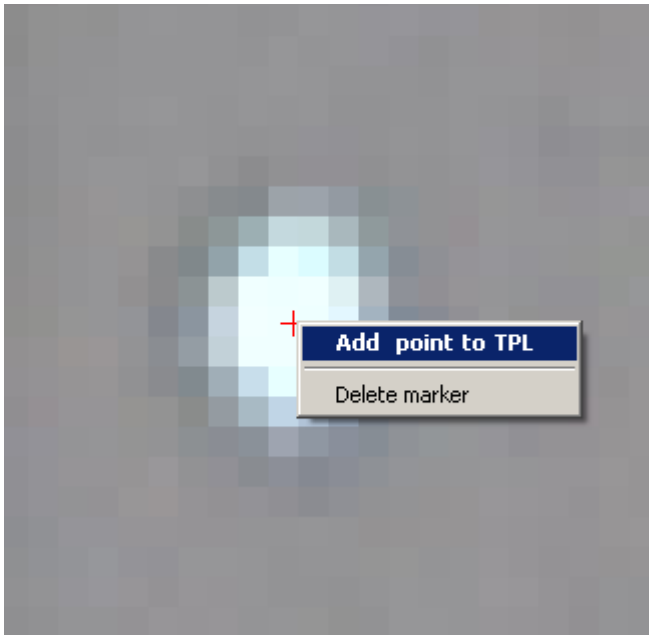
1. Generate a new node CamCalibTask in an existing project or make a new project first. To do so right-click on the CAMERA node and choose **New calibration (3D Points) …** from the menu. Confirm with OK. The new node is named CamCalibTask01 by default.

2. Right-click on the node CamCalibTask01 and select **Add image(s) …**. Add all images taken by the camera to be calibrated showing the reflector array. One image is sufficient if the reflectors cover the whole image area. Otherwise take more images by tilting and panning the camera while taking shots on the reflector array. At least 6 reflectors have to be visible in each image.

3. Import the tiepoints into the tiepoint list TPL (CALIB).

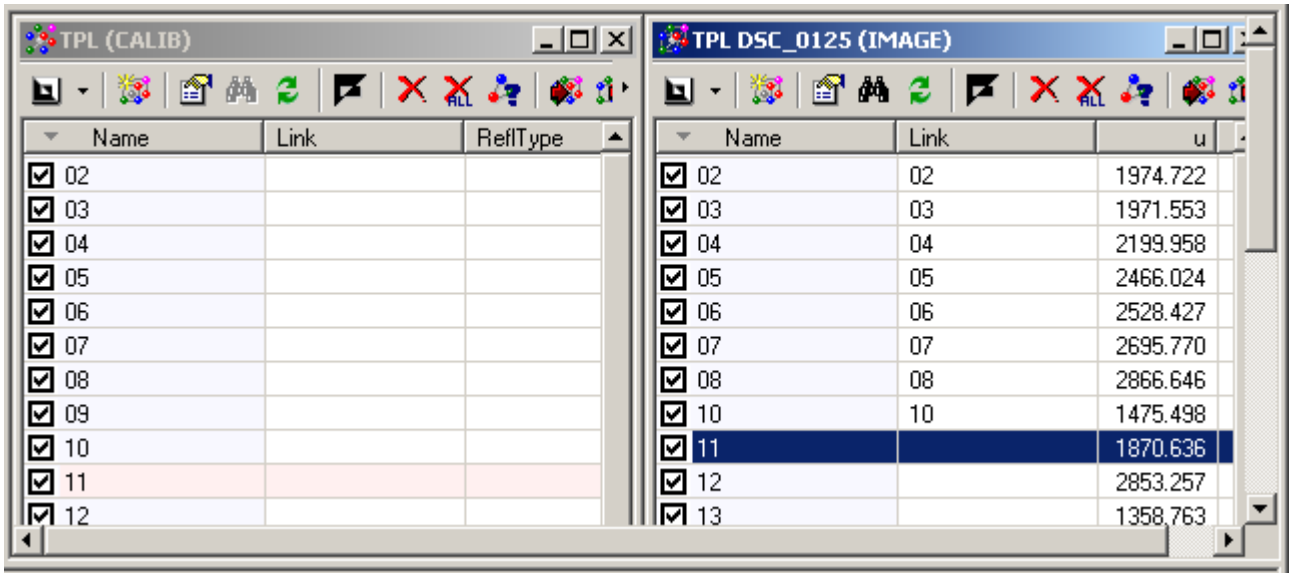
4. Process all images sequentially. For every image you have to identify the reflectors either manually or by automatic extraction (Find reflectors …). The automatic extraction works only in case the images have been taken with the flash of the camera and the reflectors show up clearly in brightness compared to the other objects.

   For the manual extraction flashing during taking the images is also of advantage. Zoom into the image, set a marker with a left-click, open the menu with a right-click on this marker and add the point to the TPL (IMAGE) .

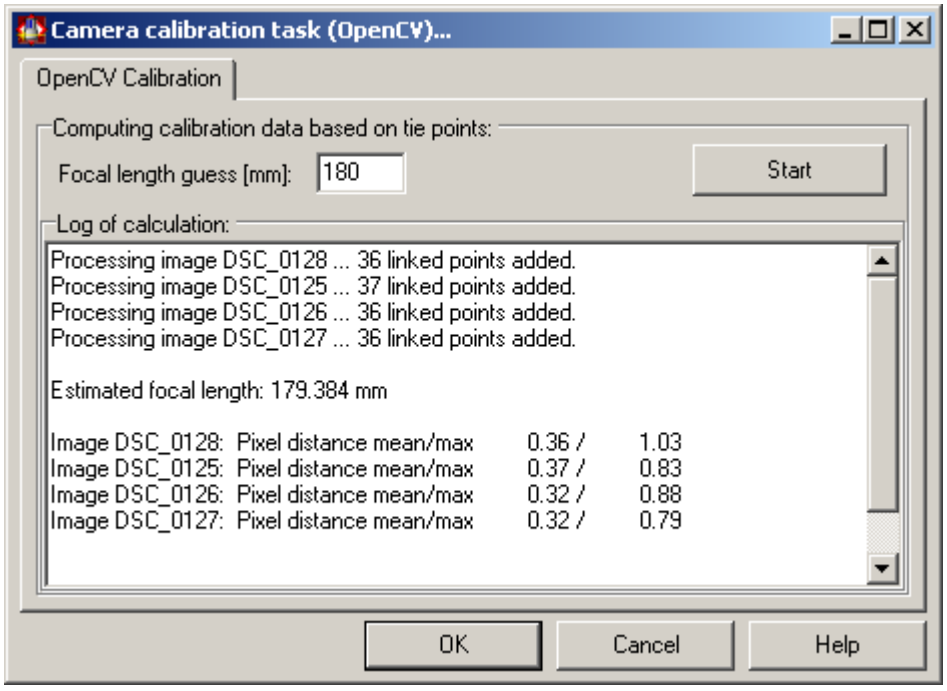


5. For every image set the correspondences between the TPL (IMAGE) tiepoints and the TPL (CALIB)

tiepoints. This is done by simultaneously displaying both tiepoint list as shown below. Establishing a link defining the correspondence is done by drag and drop . Left-click on an item's name in the TPL (CALIB) and drag it over the corresponding name in the TPL (IMAGE) and drop. You see the link in the link column. You are assisted by using the same numbering in the TPL (IMAGE), which is defined in the above step.



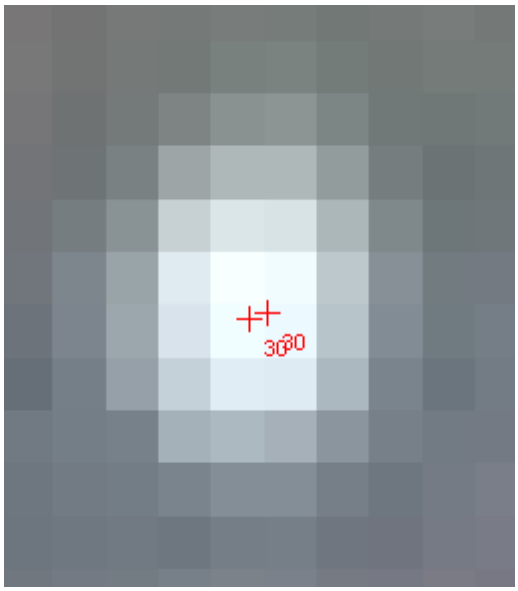
6. Open the attributes window of the node CamCalibTask01 by double-clicking or right-clicking choosing **Attributes…**. Enter the focal length guess in mm into the edit field. Use the number printed on the lens. Initialise computation of calibration parameters by clicking **Start.** All linked points are extracted from the lists and calibration parameters are calculated.



After successful calibration RiSCAN PRO displays a statistical analysis for every image. The calibration data are entered in the **Result_CamCalib** node and for every image the estimated position and

orientation of the camera in the coordinate system of the TPL (CALIB) are updated.

7. With the calibration results it is possible to check the accuracy of calibration by either displaying both the tiepoints of TPL (CALIB) and TPL (IMAGE) simultaneously in the images or by comparing the differences in pixel in the TPL (IMAGE) numerically.



TPL DSC_0126 (IMAGE)

Name	Link	u	v	du	dv	u'	v'
02	02	1875.200	1574.375	0.097	-0.220	1875.296	1574.155
03	03	1871.545	1480.316	0.221	0.177	1871.766	1480.493
04	04	2099.702	1469.512	-0.209	0.520	2099.493	1470.032
05	05	2365.688	1479.998	0.427	0.212	2366.114	1480.210
06	06	2427.970	1473.643	-0.286	-0.165	2427.683	1473.478
07	07	2595.251	1469.035	0.047	-0.031	2595.298	1469.004
08	08	2765.294	1461.727	-0.247	-0.038	2765.047	1461.689
09	09	2946.670	1452.352	-0.097	-0.165	2946.574	1452.187
10	10	1374.702	1303.535	-0.045	0.113	1374.658	1303.648
11	11	1769.601	1287.138	0.199	0.589	1769.800	1287.727
13	13	1256.437	1041.548	-0.300	0.076	1256.137	1041.624
14	14	1662.797	991.071	-0.126	0.260	1662.671	991.330
15	15	2065.064	940.537	0.121	-0.238	2065.185	940.299

Units: [deg] [m] | 36 Tiepoints, 0 selected.

8. Copy the **Result_CamCalib** for further use to the node CAMERA by right clicking on the camera calibration task and selecting "Copy Result...".

3.5.1.3 Field of view

To estimate the field of view of the camera use the following formula:

$$\Theta = 2 \cdot \arctan\left(\frac{dx \cdot Nx}{2 \cdot f}\right)$$

Variable	Meaning	Value for Nikon D100
f	focal length [m]	depending on lens
d	dimension of chip [m]	23.7mm
Nx	number of pixel in x-direction	3008 pixel
dx	dimension of one pixel in x-direction[m]	0.000 007 8m = 7.8 µm

The following table shows Θ for several lenses on a Nikon D100:

focal length	Θ
180 mm	7.5 deg
50 mm	26.4 deg
20 mm	60.8 deg
14 mm	80.0 deg

3.5.2 Tiltmount

What is a tilt mount

With a (physical) tilt mount you can tilt the scanner around the horizontal axis to predefined positions. The RIEGL tilt mount is able to tilt the scanner 180 degrees (-90° up to +90° against the vertical axis). The advantage of a tilt mount is the ability to enlarge the field of view of the scanner by scanning several times on the same position but with different tilt angles.

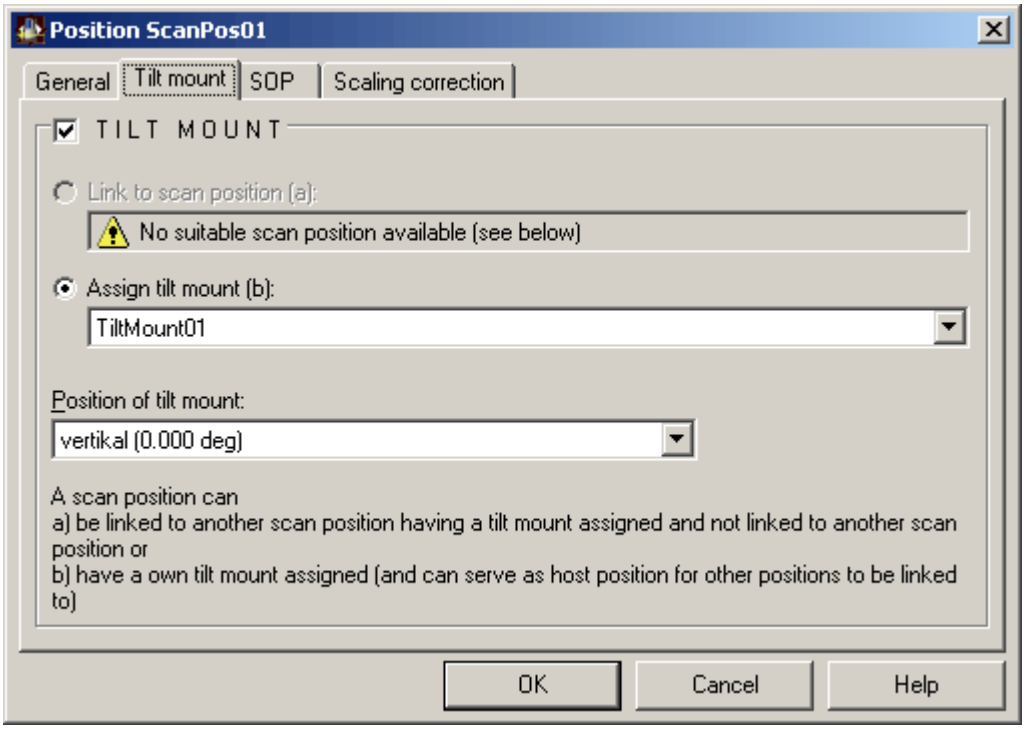
Z420 mounted on a tilt mount:

In RiSCAN PRO the scans are organized in scan positions. Everytime you move or tilt the scanner you have to create and register a new scan position. When you use a tilt mount you can speed up the registration process by using a tilt mount calibration in RiSCAN PRO. This calibration contains a complete transformation matrix for each position you can tilt the scanner to. This allows to automatically register all scan positions with the same

setup position but different tilt angles together.

General workflow of how to use the tilt mount in RiSCAN PRO

1. Create a new RiSCAN PRO project
2. Import the tilt mount calibration from your default project (please refer to "How to calibrate a tilt mount 59"). To do so open the folder "CALIBRATIONS" from the Project manager window. Right-click on the folder "TILTMOUNTS" and select "New tilt mount...". Click on the button "Import" in the lower left corner to import a tilt mount from another project.
3. Setup the scanner (no matter what tilt angle) and create a scan position
4. To assign a tilt mount, right-click on the scan position in the project manager window and select "Attributes...". The following dialog will appear:



TILT MOUNT

- *link to scan position (a)*

  select the link-target. That is the scan position which has already a tiltmount assigned (normally this would be the vertical position).

- *assign tilt mount (b)*

  assign a tilt mount to a scan position (in order to make this scan position the "base"-scan position for others)

- *position of tilt mount*

  choose a position of the tilt mount (that is the tilt angle)

In case of the first scan position you have to select option b and a proper tilt mount calibration from the list.

5. Do the data acquisition.

6. If the tilt angle changes but the position remains unchanged, right-click on the base-scan position (e.g. ScanPos01), click on "New linked position..." and select the current tilt-angle (position) from the dialog. The relationship between the scan positions will be reflected in the project manager window that way:

7. Repeat steps 5 and 6 as long as the position of the scanner isn't changed. Otherwise proceed with step 3.
8. When the data acquisition is done you may have a project similar to that example:

Name of scanposition	Scanner		Link to	Used tilt mount calibration
	Position	Tilt angle		
ScanPos01	A	0.0°	TiltMount01	TiltMount01
ScanPos02	A	+45.0°	ScanPos01	TiltMount01
ScanPos03	A	-45.0°	ScanPos01	TiltMount01
ScanPos04	B	+90.0°	TiltMount01	TiltMount01
ScanPos05	B	+45.0°	ScanPos04	TiltMount01
ScanPos06	B	0.0°	ScanPos04	TiltMount01
...				

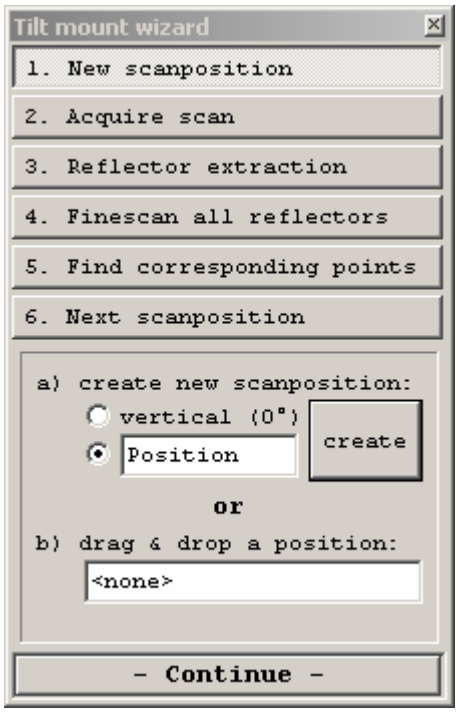
In the example the scanner was located at three different positions (A, B, C) with several tilt angles at each position. Two different tilt mount calibrations have been used (TiltMount01 and TiltMount02). Base positions are "ScanPos01", "ScanPos04" and "ScanPos07". These positions have a link to the used tilt mount calibration. "ScanPos02" is linked to "ScanPos01", so it inherits the tilt mount calibration "TiltMount01" from "ScanPos01". Due to this link "ScanPos02" as well as "ScanPos03" are already registered to "ScanPos01" (see also position B and C).

To final registration is done by registering "ScanPos01", "ScanPos04" and "ScanPos07" to either controlpoints of the project coordinate system or to each other (please refer to "Registration of a scan position 125").

How to calibrate a tilt mount

The calibration of a tilt mount is based on finescans of a reflector field at each tilt angle of the tilt mount. For each tilt position a new scan position is created and all scan position are registered onto the first (i.e. the vertical) scan position.

- Setup the scanner in the reflector field. It's recommended to use the vertical position (0°) as the first tilt position.
- Right-click on the folder "TILTMOUNTS" in the project-manager window and select "Tilt mount calibration wizard..." from the menu and follow the steps of the wizard:



1. **New scan position**
   The first step is to create a new scan position. To create the scan position with a defined name (a) select either "vertical (0°)" or enter a name and click on the button [Create]. The new scan position will be created and the name is written at (b). Click on the button [Continue].

2. **Acquire scan**
   Now you can acquire a scan (an "Overview scan 69"). That scan should contain all desired reflectors of the reflector field. By clicking on the button [Start] the normal scan dialog is opened. Please choose the proper scan area and scan pattern and start the data acquisition.

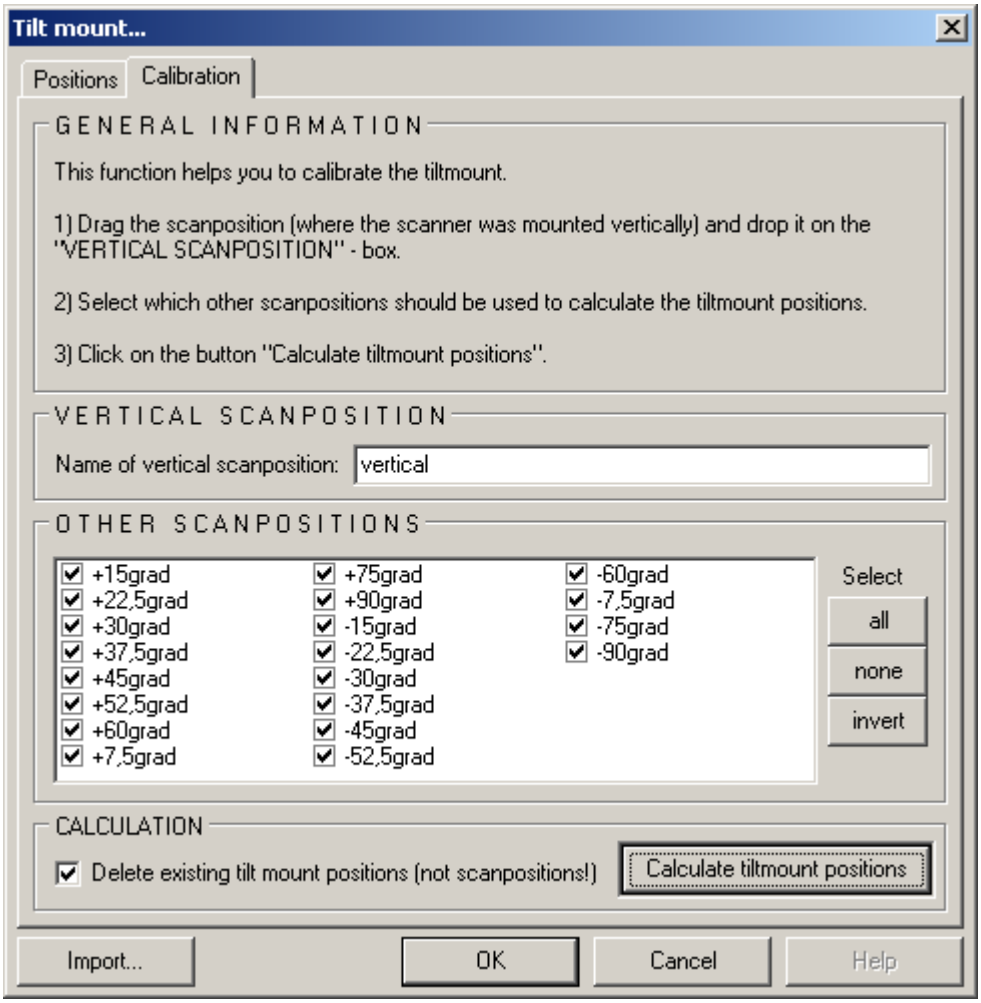
3. **Reflector extraction**
   Now the reflector extraction can be done. On this page you can see/modify the scan used for the reflector extraction. To start the reflector extraction click on the button [Start]. The extracted targets will be added to the TPL SOCS of the current scan position.

4. **Finescan all reflectors**
   At this step all reflectors of the TPL SOCS of the current scan position are fine scanned. Of course you can modify the TPL SOCS before the finescans are started (e.g. to delete faulty detections, not needed targets...). Therefore the TPL SOCS is opened automatically at step 3. Cleanup the TPL SOCS and click on the button [Start] in order to start the data acquisition.

5. **Find corresponding points**
   If this is the first scan position of the calibration procedure you can skip this step (you will be asked by the wizard).
   Now the registration of the position onto the vertical (i.e. the first scan position) is done. On this page you can select the vertical scan position (allready preselected by the wizard). Click on the button [Start] to show the "Find corresponding points..." dialog. In the box "REFERENCE COORDINATE SYSTEMS" the vertical scan position is preselected. Click on the button [OK] to start the procedure.

6. **Next scan position**
   The data acquisition of the current scan position is done.

- If there are tilt positions left to be calibrated than click on the button [Start]. The wizard continues with step 1.
- If the data acquisition of all tilt positions is done click on the button [Acquisition finished,...]. The following dialog appears:



In this dialog you can see a summary of all acquired scan positions (box "OTHER scan positionS"). You can decide which scan positions should be used for the calibration (by default all). You have also to define the vertical scan position. That is the scan position you have registered all other scan position on (by default the first scan position). If the pre selection of the vertical scan position is not correct please drag & drop an other scan position from the list onto the box "VERTICAL scan position". To start the calibration (=calculation of the matrices for each tilt position) click on the button [Calculate tiltmount positions]. The matrices will be calculated. You can see the result on the first page "Positions" of this dialog.

The calibration of the tiltmount is finished now. To save the result please click on the button [OK] and save the project.

Part IV

Data acquisition

4 Data acquisition

4.1 Scan acquisition

General

Before acquiring a new scan make sure that the device is correctly connected, switched on and the communication ports are set properly (for more information about communication ports see also "Getting started: Create new project: Project settings 33").

Each acquired dataset is saved in a scan file (3DD) within the folder "SINGLESCANS", "SCANSEQUENCES" or "TIEPOINTSCANS" within the scan position. In which folder the scan is saved depends on the type.

Scan type overview

Singlescans:

Contain just one view (also called "frame") of the selected range. This represents a 3D snapshot of all targets within the field of view of the instrument at acquisition time.

Scansequences:

Contain several views (frames) acquired directly after each other. Scansequences can be used for instance to scan a frequented street. Because each frame is acquired at different time it is likely that almost all interfering targets (cars, pedestrians) can be filtered out by combining all frames. See "Data postprocessing: Resample 148".

Tiepointscans:

Tiepointscans are high resolution scans of points of interest (i.e. reflectors). See "Tiepoint scans 90".

Scan acquisition

In order to make a new scan click with the right mouse button on a scan position and select "New single scan..." or "New scansequence" from the menu. As an alternative you can also make a detail scan of an already acquired scan (just click on the scan instead of the scan position). A dialog containing three pages appears:

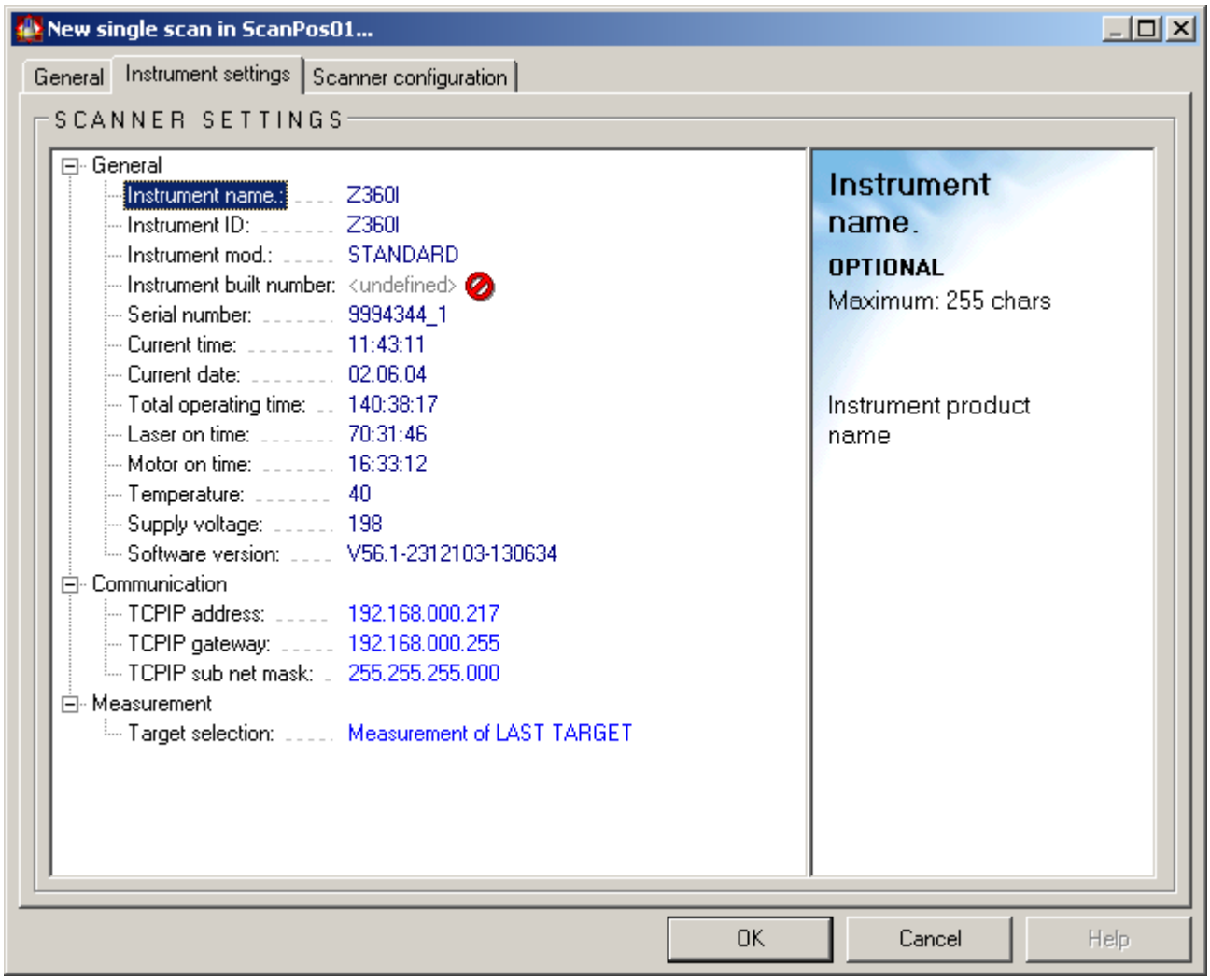
General

On this sheet you can insert comments like operator, date, location and so on.

Instrument settings

This sheet provides a tree-view with several extended settings and information about the instrument. Which and how many settings are available depends on the instrument you use.

Example for Z360:



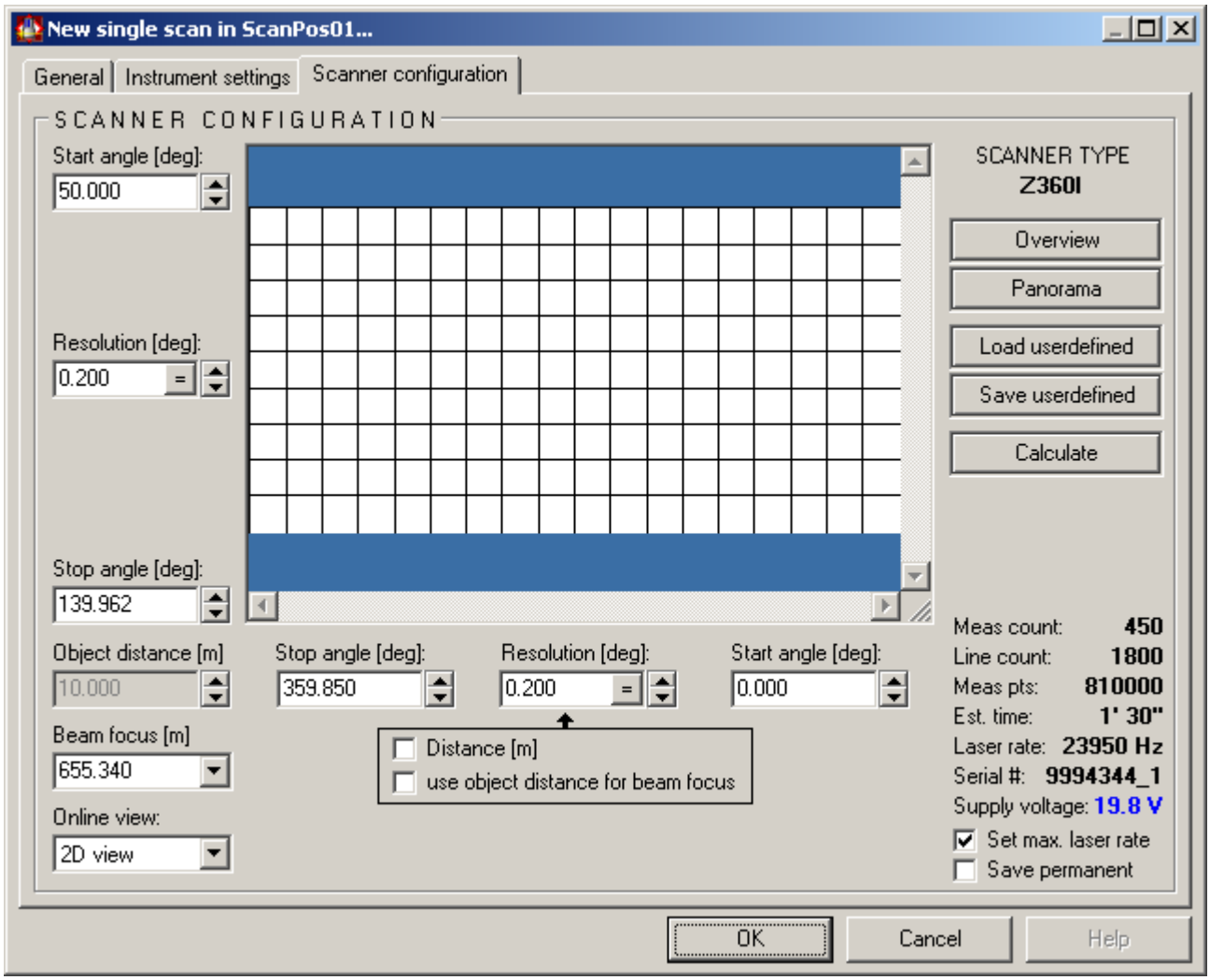
Scanner configuration (displayed as first page)

When the dialog is displayed, this page is displayed at first and RiSCAN PRO tries to connect to the instrument and requests several settings.

During this procedure no changes can be done (the input fields are locked =gray color) and the dialog can only be closed by clicking on [CANCEL] (no scan will be taken).
When this procedure succeeds the input fields will be unlocked (=white color) and you can start to configure the scan. If no communication with the instrument can be acquired the input fields stay locked and an error message will be shown. Try the following:

1. check the batteries
2. check the cables
3. check the communication port (see "Getting started: Create new project: Project settings 33")

With the page "Scanner configuration" you can configure the scanpattern, that the instrument should use to acquire the data. The layout of this page depends on the used instrument. At least the dialog looks like shown in the following image:



The scanpattern is made up by following parameters:

phi start angle, **phi resolution**, **phi stop** angle (horizontal scan area)
theta start angle, **theta resolution**, **theta stop** angle (vertical scan area)
Beamfocus (only available for instruments Z360 and Z360i)

To configure the scanpattern you can either use one of the default scanpattern buttons ("Overview 69", "Panorama 70"), load a previously saved scanpattern (button "Load user defined"), or enter the parameters manually. When you enter the parameters manually click on the button "Calculate" in order to update the information shown in the bottom right corner of the dialog.

Visual scan area definition:

The grid in the center of the dialog can be used to define the scan area (start and stop angles). The grid has a resolution of 20° deg. To define the scan area, move the mouse over the grid, hold down the ALT key, press the left mouse button and draw a rectangle by moving the mouse. Unpress the left mouse button to finish the selection - the start and stop angles are updated.

Note: When you have opened this dialog by clicking on a scan (see above: "Detail scan 65"), instead of the grid the scan will be displayed.

Measure object distance (only available for detail scans 65, described above)**:**

To get a quick reference for the distance of a certain scanned object, click with the left mouse button onto the object. This will set a marker. You can also click several times. In that case "Object distance" will display the average of all measurements.

To see how you can move and delete markers, please refer to "Data visualization: 2D view: Navigation 100".

Online view during data acquisition

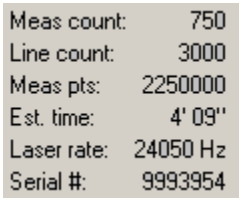
You can observe the scanning progress by selecting the online view property.

There are three items:
<none> - no online view is displayed
2D view - a 2D online view 96 is displayed
3D view - a 3D online view 102 is displayed

Note: On slower PCs please select 2D view or even disable the online view. Otherwise you will risk loss of data because of performance problems!

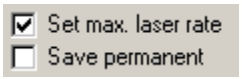
Scanpattern and instrument information

In the bottom right corner you will see some additional information of current scanpattern



... number of measurements per line
... number of lines per frame
... number of points to measure
... estimated time

... serial number of scanner device

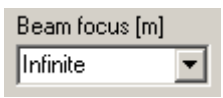


... sets the laser rate to the maximum (recommended)

... all parameters will be saved permanent in the instrument

Setting the beamfocus (only available for instruments Z360 and Z360i)**:**

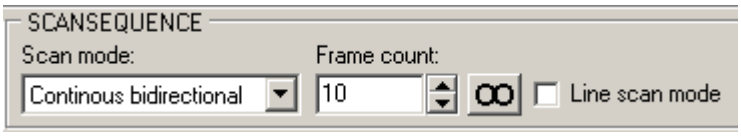
To set the beam focus use the "Beam focus" list. You can select "Infinite" or set a beam focus by yourself. That means that you can edit the "Beam focus" combo box by input a distance to which you want to set the focus.



(not always available)

When you activate the option "Use object distance for beam focus" the current selected object distance (see above) will be taken to set the beam focus.

Additional settings for scansequences:

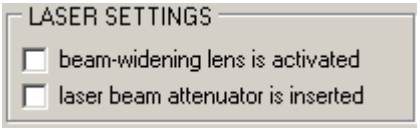


There are 3 scan modes:
Continuous bidirectional - the scanner is scanning in two directions
Triggered unidirectional - the scanner is scanning in only one direction
Triggered bidirectional - the scanner is scanning in two directions, controlled by software

Frame count
Number of scans within one scansequence. You can also set this to infinite.

Line scan mode
Perform only a single line scan at the horizontal start angle defined.

Additional laser settings for Z420 and Z420i:



Beam-widening lens:
The instruments Z420 and Z420i have a so called "beam widening lens". This lens enlarges the laser beam divergence from 0.25 mrad to 2.0 mrad. The beam widening lens is used within a Panorama scan 70 in order to enhance the probability to detect all reflector targets within the scene.

Laser beam attenuator (applies only to Z420):
The laser beam attenuator is an optical filter, reducing the laser beam intensity when inserted.

ATTENTION:
Be cautious when using a scanner without laser beam attenuator.
The following dialog will appear when you are scanning without attenuator:

Finish configuration / start scan:

When you have finished configuring the scanpattern you may want to save it. To so click on the button "Save user defined". The scanpattern will be saved in the folder "COLLECTIONS / CONFIGS" within the project for future usage. Double click on a scanpattern to edit it.

To finally start the data acquisition click on the button "OK". A short summary of all settings will be displayed. Acknowledge this information by clicking on the button "OK". Now the online view is opened (if selected) and the data acquisition is started. You can watch the progress of the data acquisition either in the online view or in the thread list window 14.

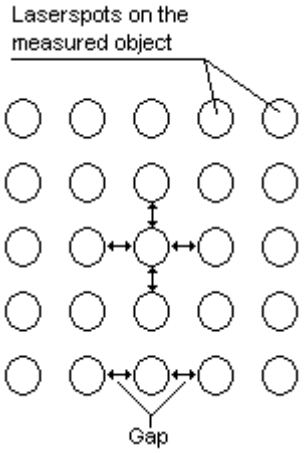
4.1.1 Overview scan

The scanpattern "Overview" (Overview scan) is thought to give you a quick overview of the scan area.
The overview scan is a scan with full field of view of the scanner.

Example:

Z360(i): 90 deg vertical and 360 deg horizontal field of view; takes approx 1.5 minutes to acquire
Z420(i): 80 deg vertical and 360 deg horizontal field of view; takes approx 1.5 minutes to acquire

The angular resolution of the scan is set to 0.200 deg
Each instrument has a smaller laser beam divergence than 0.200 deg Therefore there are gaps between the laser spots on the object (see figure below).



4.1.2 Panorama scan

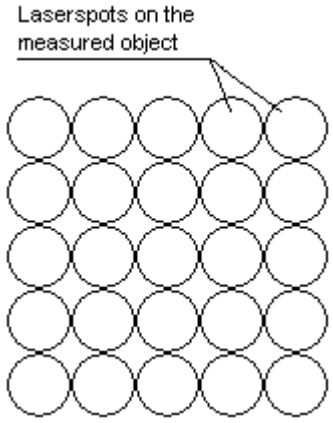
The scanpattern "Panorama" (Panorama scan) is used to acquire data within the complete field of view of the scanner with higher angular resolution than the Overview scan 69. With the Panorama scan any reflector target within the field of view (and range) of the scanner will be detected.

Example:

Z360(i): 90 deg vertical and 360 deg horizontal field of view; takes approx 4 minutes to acquire
Z420(i): 80 deg vertical and 360 deg horizontal field of view; takes approx 4 minutes to acquire

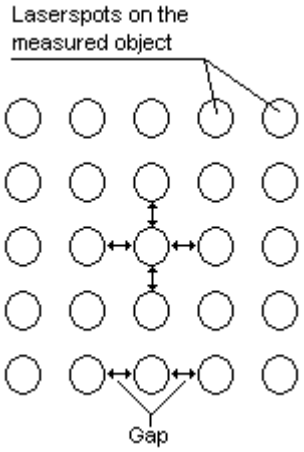
The angular resolution of the scan is set to 0.120 deg

Concerning the **Z360(i)** that means that the laser spots are side by side without gaps (the complete surface is scanned):

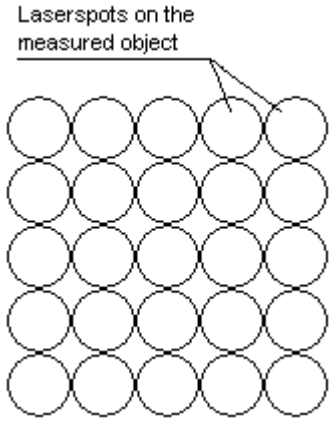


Concerning the **Z420(i)**, which has a lower laser beam divergence, that means that there will be gaps between the laser spots as it can be seen in an Overview scan 69. Therefore this instrument has an beamwidening lens. With this lens it is possible to enlarge the laser beam divergence and to make a Panorama scan without gaps (compare figures below):

Beamwidening lens **deactivated** (laser beam divergence 0.25 mrad):



Beamwidening lens **activated** (laser beam divergence equal to angular resolution = 2 mrad):



When using the Z420(i) it's recommended to activate the beamwidening lens in order to detect all reflector targets.

4.1.3 Inclination sensors (optional)

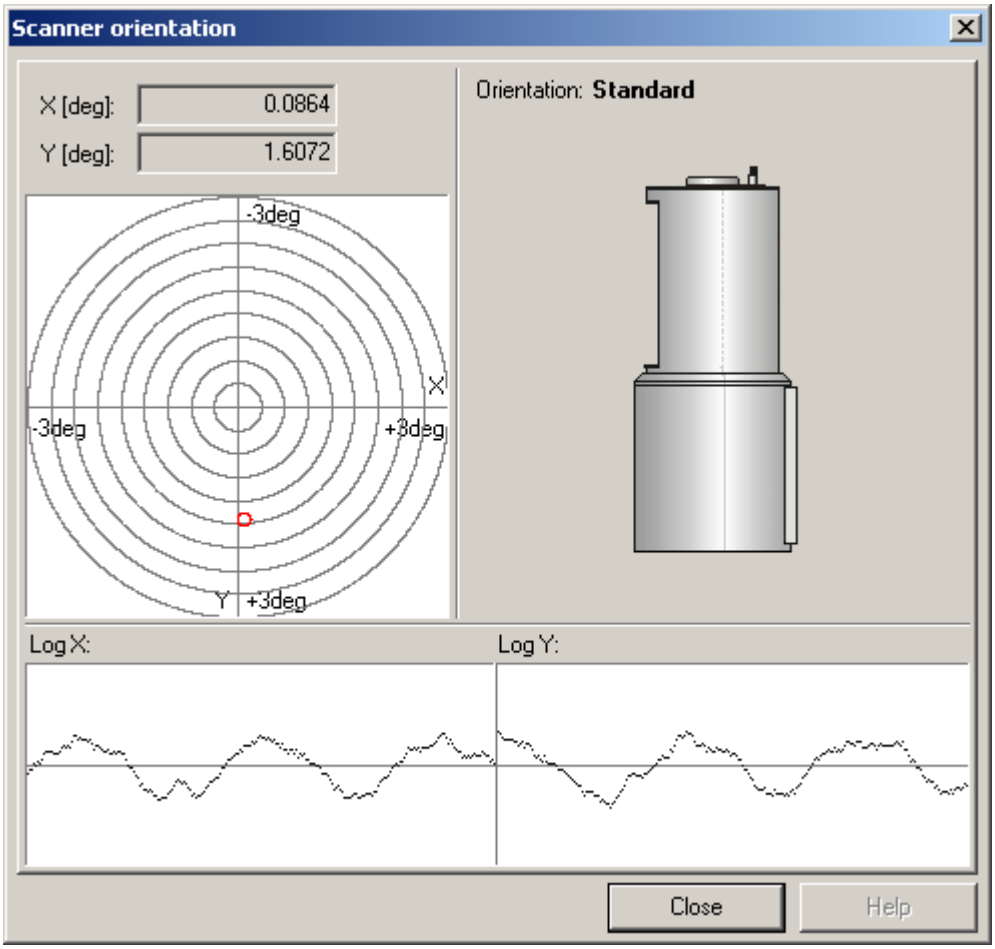
Some RIEGL LMS 3D laser scanners can optionally be equipped with inclination sensors. With this inclination sensors it's possible to measure the inclination of the instrument around the X, Y and Z axes. These sensors have a measurement range from approximate -5 deg to +5 deg This chapter describes how these sensors can be used in RiSCAN PRO.

Shock detection during data acquisition

During the data acquisition RiSCAN PRO checks the change of inclination values from data line to data line. If the change is greater than 0.5 degrees (e.g. when somethings hits the scanner or the tripod), RiSCAN PRO displays a warning message in the message list. This warning is also displayed everytime you open the scan.

Aided manual alignment of the instrument

RiSCAN PRO has a built-in level tool. With this tool you can manually align the instrument vertically or horizontally.
To open the tool please click on the menu "Tool" and select "Scanner orientation" from the menu. The following dialog will appear:



On the right side of the dialog you can see a sketch of the instrument representing it's coarse alignment. This sketch will show one of the following five alignments:

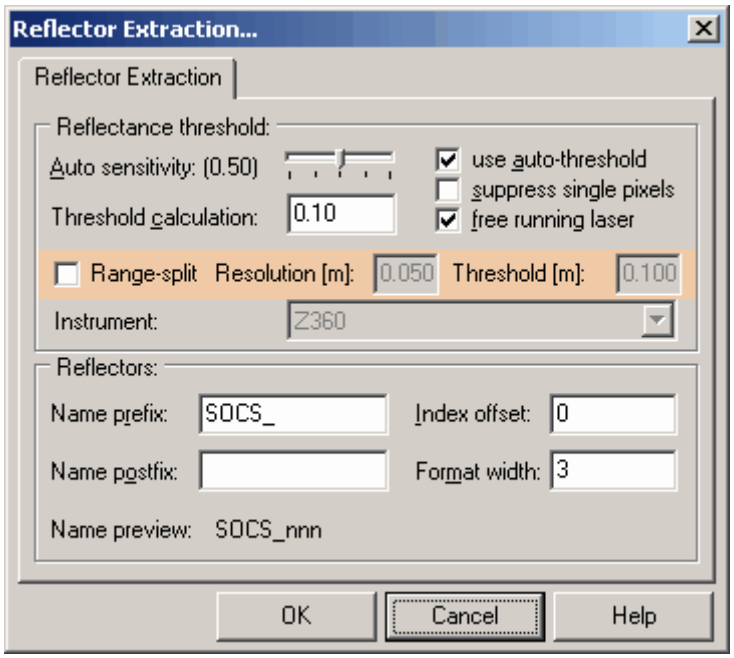
Standard	vertically aligned, head up	rotation about X and Y axes
Lay back	vertically aligned, mounting plate down	rotation about Y and Z axes
Top down	horizontally aligned, head down	no values available
Lay front	horizontally aligned, mounting plate up	no values available
Unknown	the tilt angle is out of range	no values available

Please note, that the inclination sensors will only provide angle values at the alignments **Standard** and **Lay back**.

The left part of the dialog shows the current rotation of the scanner about the scanner axes (either X & Y or Y & Z) in both a numerical and a graphical manner.
On the bottom side of the dialog you can see a chart showing a log (=history) of the inclination angles.

4.1.4 Reflector extraction

This function extracts all retro-reflective objects of a scan and writes the coordinates of them into the corresponding tiepointlist. To run the reflector extraction right-click on a scan and select "Find reflectors...".



Reflectance threshold:

- *Auto sensitivity:*

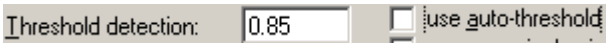
  Range: 0..1
  Default: 0.5
  Meaning: Sensitivity of the algorithm. A higher value means that more reflectors will be found. Be careful with setting this value. With high sensitivity the process lasts very long (also depending on the size of the scan) and it's quite sure that a lot of "wrong" objects are detected.

  Note: This is only available when "use auto-threshold" is selected.

- *Threshold detection*

  Range: 0..1
  Default: 0.85
  Meaning: Only objects with a higher intensity (=reflectivity) than this value will be recognized as reflectors.

  Note: This value is only available when "use auto-threshold" is not selected:

- *Threshold calculation*

  Range: 0..1
  Default: 0.10
  Meaning: This is used within a found reflector to exactly determine the center.

- *use auto-threshold*

  This switches between calculation of threshold-detection and manual input of threshold-detection.

- *suppress single pixels*

  Objects represented only by one single pixel will be ignored.

- *free running laser*

  Check this box, when the scan was acquired by a scanner in "free-running laser" - mode.

- *Range-split*

  Selecting this option will define the minimum distance between the reflectors. This is important, if reflectors are placed very close aside each other to ensure the scanner to detect each reflector.

Reflectors:

- *name prefix*

  The name of the tiepoint starts with this prefix

- *name postfix*

  The name of the tiepoint ends with this postfix

- *Index offset*

  Range: at least 0 (Zero)
  The numbering of the tiepoints starts at this value. This value is automatically set to the first unused number but can be changed by the user.

- *Format width*

  Range: 1..20
  Default: 3

  The number of digits used for the tiepoint-naming-process.

- *Name preview*

  This shows an example for a tiepoint name generated by the current name-format settings.

4.2 Image acquisition

This chapter describes how to take a single photo or a series of snap shots from a scan position.

Important note: the following conditions have to be met before the Image acquisition can be used:

- The camera must be properly connected to the PC, laptop or camera server respectively.
- a camera type has to be assigned (see Create new project 32)

- the camera plugin has to be installed (if the plugin is not installed, download it from the RiSCAN PRO download page 202)
- If you notice problems when connecting to your camera directly through RiSCAN PRO, please check the "USB protocol" setting of the camera. This value must be set to "PTP" for NIKON cameras and to "normal" for CANON cameras. For changing this setting please refer to the product documentation of your camera.

With RiSCAN PRO and the connected camera you can easily take a photo with the digital camera mounted on the scanner.

Taking a single photo with RiSCAN PRO

To take a photo right-click a scan position or on the "OBJECTS / IMAGES" folder and select "New single image...".
This will show a dialog with several pages:

Sheet "General"

On this page you can enter some comments about the photo (location, date, settings of the camera,...).

Sheet "Calibrations"

On this page you have to select the camera calibration (according to the camera and the lens) and the mounting calibration (only available on images within a scan position). When the project contains more calibrations you may also define one calibration as "default". In that case this calibrations will be selected automatically on this page. To define a calibration as default calibration, click with the right mouse button on the calibration and select "Default" from the menu.

Sheet "Position & Orientation"

The position and orientation of the camera (see "Embedding images into the project" for more details). This matrix is also called COP matrix. The COP matrix is determined by RiSCAN PRO automatically when the images are saved at the scan position. When you acquire an image saved at the folder "OBJECTS / IMAGES" the matrix stays unchanged. In that case see Registration of project images 139.

Sheet "Summary"

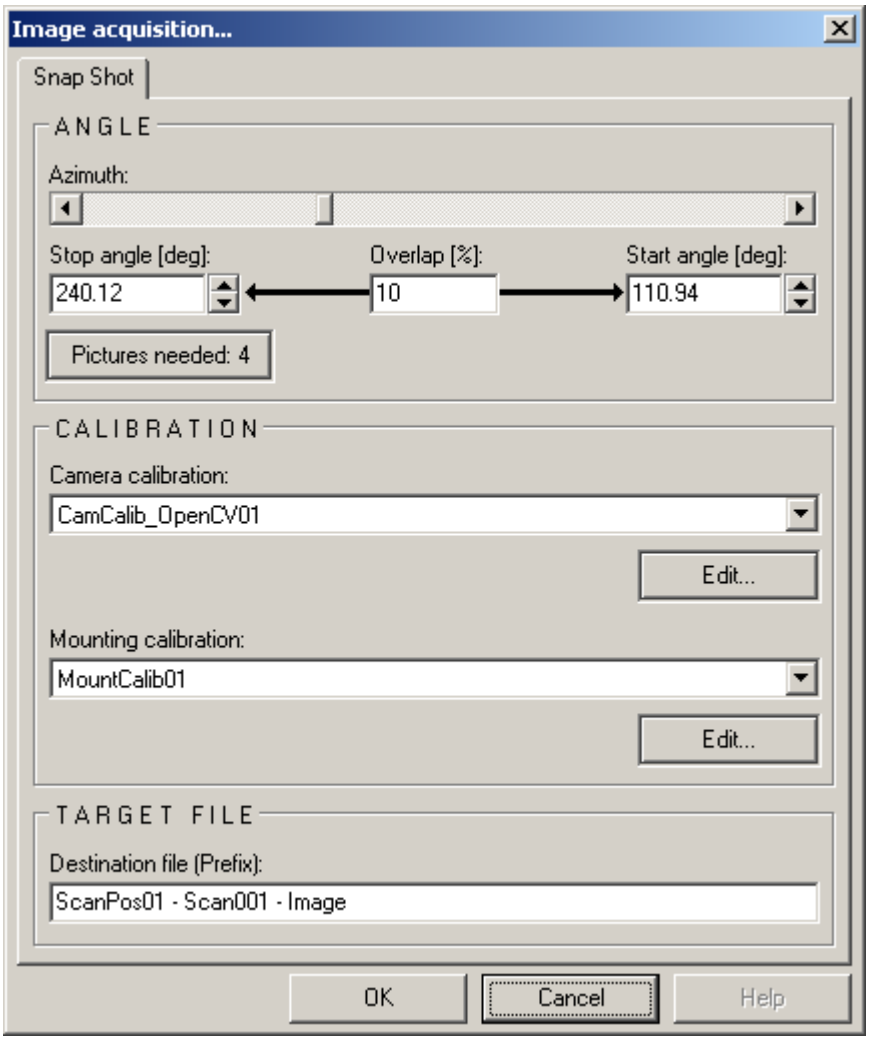
This page will hold information about the photo *after* taking it such as size, color depth and resolution.

Finally click on "OK". The photo will be taken and saved within the project structure.

Acquisition of a series of images

With this function you can take a series of photos in order to cover a given area. During this process the digital camera is mounted on the scanner and the scanner is turning from one snapshot position to the next. At each snapshot position the scanner stops and the camera takes a photo.

To start the image-acquisition process right-click on a scan or a scan position and select "Image acquisition..." from the menu.
This will show the following dialog:



ANGLE

You can adjust the area which the photos should cover by editing the *start*- and the *stop-angle*.
The *overlap factor* means how much (in percent) of the images will be overlapped (default value is 10%).
Pictures needed shows how much pictures will be taken in order to cover the whole area. Note that this value isn't recalculated when you change the angles, the overlap factor or the camera calibration. To recalculate this value you just have to click on "Pictures needed" and the correct number of pictures will be shown.

CALIBRATION

In this area you have to set the camera calibration 36 and the mounting calibration according to the camera, the lens and mounting used.

TARGET FILE

This will be the prefix of the saved photo (generated automatically, but editable).
In the example from above the photos will be named:

ScanPos01 - Scan001 - Image 001
ScanPos01 - Scan001 - Image 002
ScanPos01 - Scan001 - Image 003

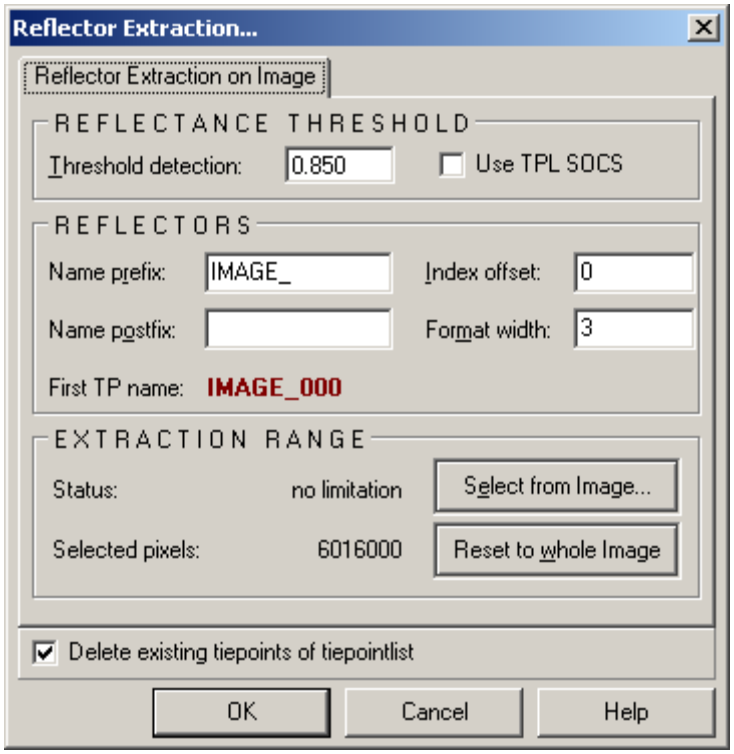
ScanPos01 - Scan001 - Image 004

To finally start the image acquisition just click on the button "OK"**.**

4.2.1 Reflector extraction

This function extracts all retro-reflective objects of an image and writes the coordinates of them into the corresponding tiepointlist.
The reflector-extraction of an image is needed for calculating the camera mounting or the camera calibration.

To run the reflector extraction right-click on an image and select "Find reflectors...". This will show following dialog:



Reflectance threshold:

- *Threshold detection:*

  Range: 0..1
  Default: 0.85
  Meaning: Only objects with a higher intensity (=reflectivity) than this value will be recognized as reflectors.

- *Use TPL SOCS:*

  When you active this option, the tiepoints are searched based on the tiepoints of the TPL SOCS transformed into the image. The found tiepoints will be linked with the corresponding SOCS tiepoints automatically. This function can be used for the camera calibration and for the readjustment of the Mounting calibration.

Reflectors:

- *Name - format:*

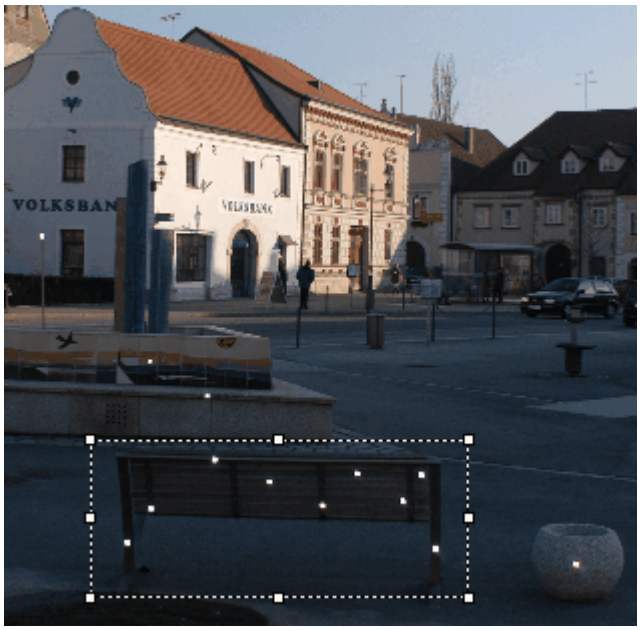
see "Reflector extraction (Scan) / Name format 73" for information about formating the reflector-name.

Extraction range:

You can select the range within which the reflector search will be done. This is usefull, when there are a lot of light spots in the image which should not be handled (recognized) as reflectors.
The default extraction range is the complete image. So "Status" is "no limitation" and "Number of pixels selected:" shows the total number of pixels of the image.

To select the range just click on "Select from Image...". This will hide the dialog and show the image. You can now make your selection:

Rectangle selection: Hold down the "ALT" - key and the left-mouse-button and move the mouse to draw the rectangle window.

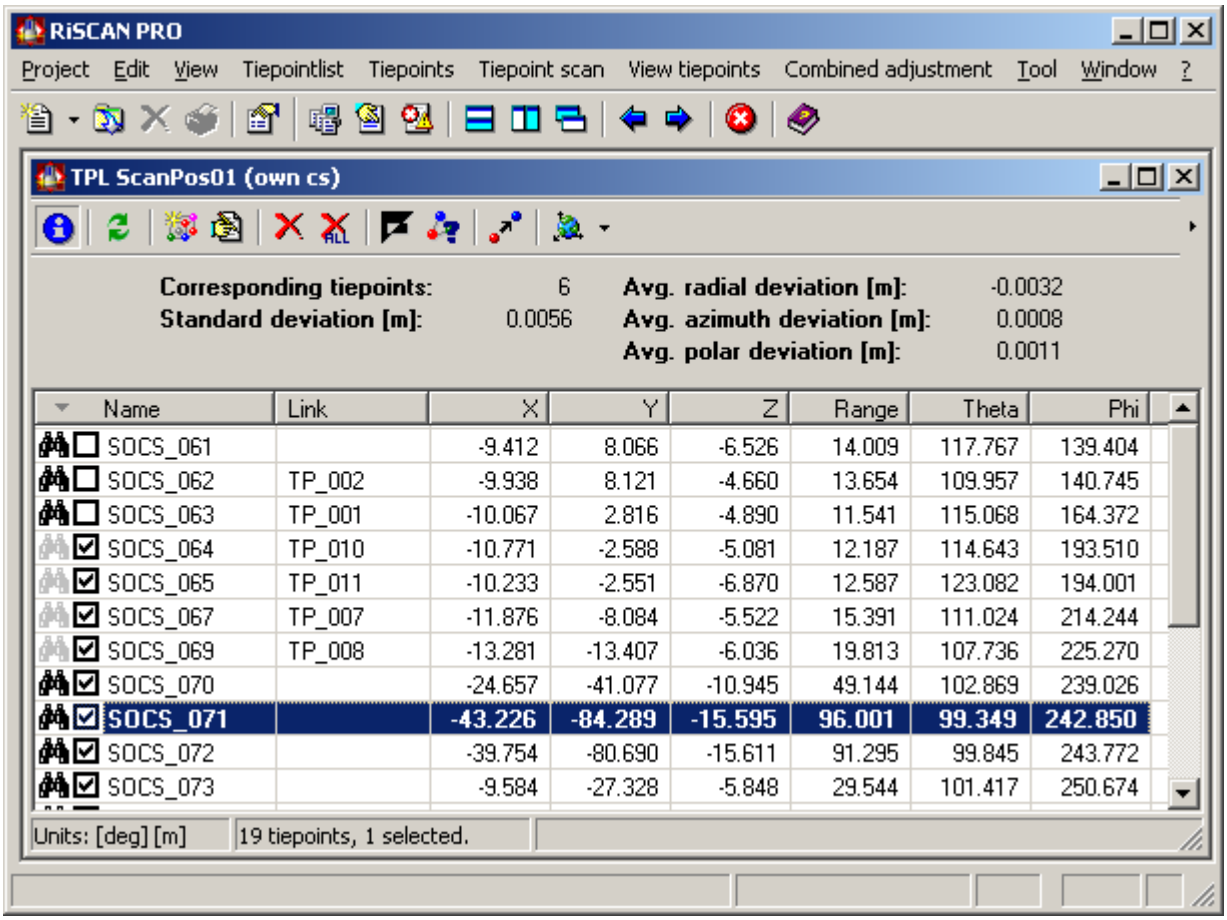


After you have done the selection hit the right-mouse button to return to the "Reflector Extraction..." dialog. By clicking on [OK] the reflector extraction will be done only within the selected range.

4.3 Tiepointlist window

Within the tiepointlist window you can manage the tiepoints.
The style of the tiepointlist window depends on the tiepointlist it represents and on the user-defined column selection.

The following graphic shows a screenshot of a TPL window of a scan position with the most important columns.



The tiepointlist-window is divided into three parts:

1. The icon-bar
2. The additional information area
3. The list showing the tiepoints

1. The icon-bar

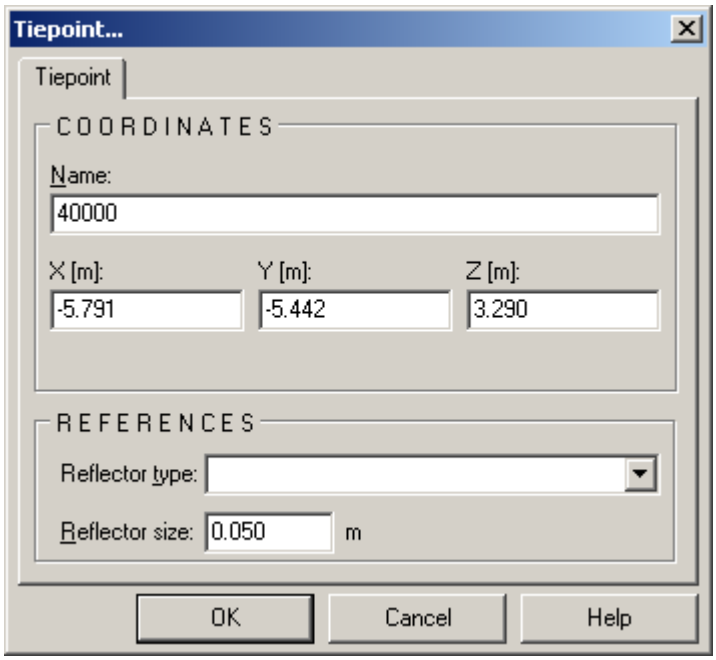
The icon-bar contains the most important functions available for the tiepointlist. All these functions (and a lot more) are also available in the menu of the main window of RiSCAN PRO.

- **Switch On/Off additional information** (only available in TPL SOCS)

  This shows or hides the additional information.

- **Add a new tiepoint**

  This will show the "New tiepoint..." dialog.
  With this dialog you can add a new tiepoint to the list.
  The style of this dialog depends on the tiepoint you want to create. Basically this dialog offers input fields for the coordinates (TPL of a Image: "u" and "v" otherwise "X", "Y" and "Z") and the tiepoint name:



With "Reflector type" you can select the type of the reflector represented by this tiepoint. When you choose a reflector the coordinates are recalculated corresponding to the type and dimension defined in the reflector calibration. Note that the coordinates will not change when "Keep values on change" is selected (by default this option is not activated)!

Note: The usage of "Weight" is not implemented yet!

An alternative way to add new tiepoints is by using the 2D-Window or the 3D-Window.

To add a **new tiepoint via a 2D window** set a marker fist by clicking with the left mouse button onto the pixel you want to add as a tiepoint. You will see the marker. Then right-click on the marker and choose the option "Add point to TPL". The dialog shown above appears with the coordinates of the marked point.

To add a **new tiepoint via a 3D window** right-click onto the point of the point cloud you want to add as a tiepoint to the TPL. The point is highlighted as a pick point. To improve the visibility of the pick point set the pick point size larger, e.g., 5 pixels. This can be done via the options settings in the 3D - View or as a general setting in the program settings in the 3D section.

- **Edit tiepoint**

  Enables you to edit the tiepoint (name, coordinates and so on)
  Note: This function is only available, when ONE tiepoint is selected.
  The dialog to edit the values of a tiepoint is the same as the "New tiepoint..." dialog (see the section "Add a new tiepoint 78" above for more information about this dialog).

- **Delete selected tiepoint(s)**

  Deletes the selected tiepoint(s) after a confirmation.
  Note: You can NOT undo this action!

- **Delete all tiepoints**

  Deletes all tiepoints after a confirmation.

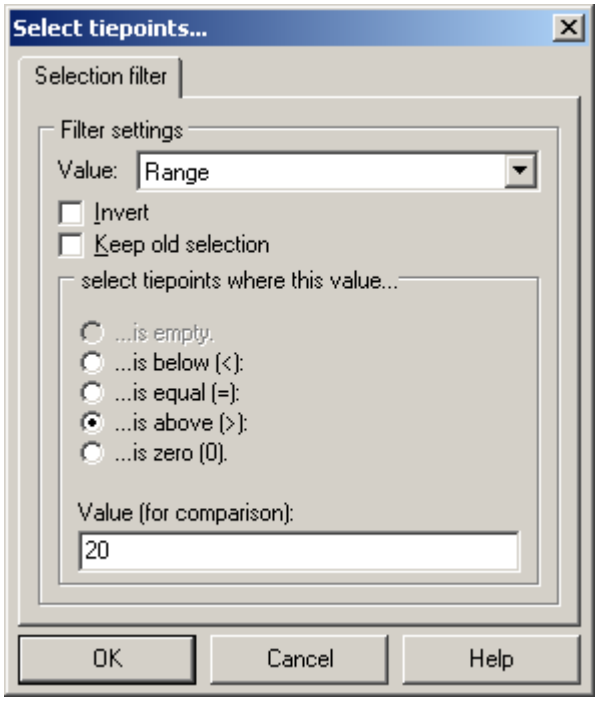
Note: You can NOT undo this action!

- **Invert tiepoint selection**

  Inverts the selection of the tiepoints (Selected tiepoints are de selected and vice versa).

- **Selection filter**

  This is a tiny tool to select all tiepoints matching a given criteria:



  To use this tool just select a value (column) and the criteria (above, below, equal to,... this value).

  When "Invert" is checked the result of the filter tool is inverted.

  When "Keep old selection" is selected all tiepoints selected before using this tool are also selected after using it (works like an OR filter).
  So you can realize a "multiple" selection by running these tools with different settings but "Keep old selection" checked.

- **Find corresponding points** (only available in TPL SOCS)

  see "Registration via tiepoints 125"

- **Coordinate system** (not available in TPL IMAGE)

  By clicking on the arrow below this icon you get a list of coordinate systems where the tiepoints should be displayed in. By selecting one of the coordinate systems the data is reloaded and automatically transformed into this coordinate system.

  By clicking on the icon itself you can reset the coordinate system to that one of the tiepointlist (no transformation will be applied).

2. The additional information area (only available in TPL SOCS)

In the additional information area the deviations between the tiepoints an their corresponding (= linked) tiepoints is shown.

3. The list showing the tiepoints

This list shows all tiepoints of the tiepointlist.
The style (columns to display) of the list can be set with the layout-editor 78

The checkbox in front of the name of the tiepoint shows the combined-adjustment-usage.
The binoculars in front of the name of the tiepoint shows the visibility-state.

You can click on the symbols to change the states.

To link two tiepoints together you can drag one tiepoint and drop it over an other tiepoint of an other tiepointlist.

4. Other functions (available from the menu-bar)

- **Menu "Tiepointlist"**
  - *Calculate translation for POP (only available in TPL GLCS)*

    This calculates and writes the translation in x,y,z - direction for the POP matrix.
    This transforms the "huge" numbers of the TPL GLCS to smaller numbers in the TPL PRCS to make all further calculations more precise.

    Usage:

    -) Select "Calculate translation for POP" from the menu

    -) a dialog appears showing the calculated translation. You can edit the translation. To finally write the translation to the POP matrix press the button "OK" else hit "CANCEL"

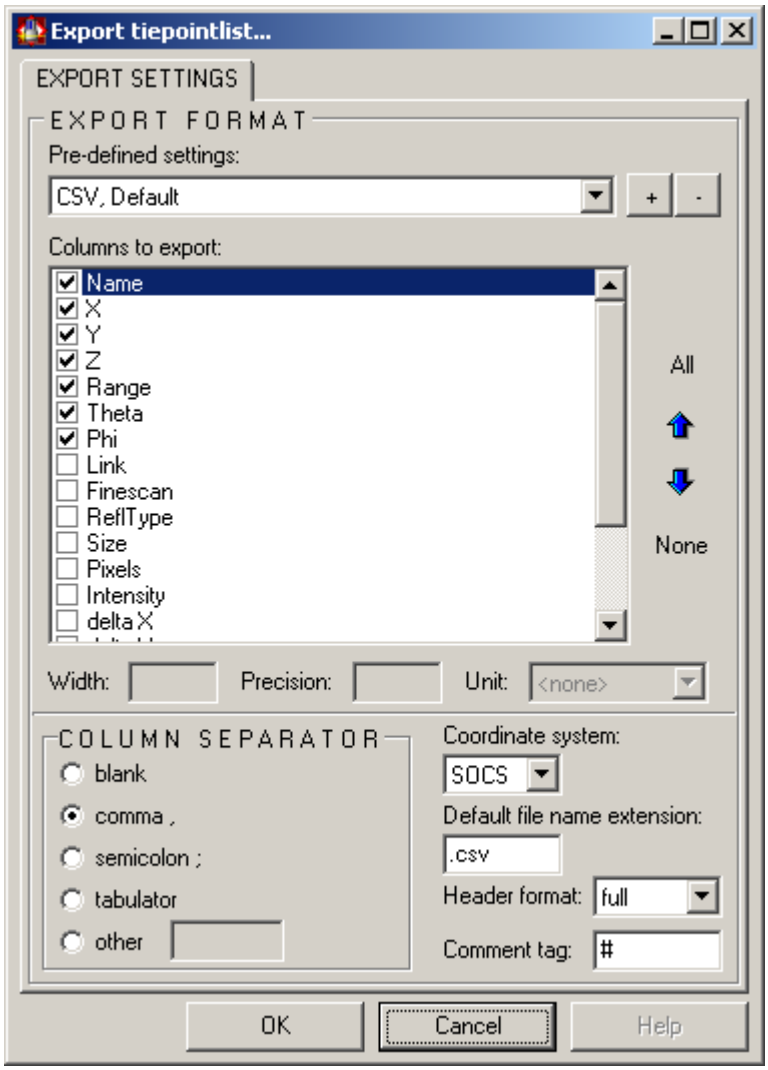
    Optionally:

    -) Use the Copy selected tiepoints to... 78 TPL PRCS" to copy and transform the tiepoints to the TPL PRCS.

  - *Export*

    To export tiepoints in a common format (text file) select some tiepoints and select "Export" from the menu "Tiepointlist". If no tiepoints are selected, you will be asked if all tiepoints should be exported.

    To configure the export format use the following dialog, which appears after clicking on "Export".



There are several settings you can make:

Column selection and order:
You can select which columns should be exported in which order by checking / unchecking and dragging & dropping the columns.

Value width and precision:
Select a column containing numerical data (e.g. X,Y or Z) and set the width and precision to serious values.

Value unit:
Select a column containing data with physical units (e.g. X,Y,Z,Theta,Phi) and select the unit from the drop-down box "Unit:".

Column separator:
This character will be inserted between the exported columns (e.g. "tabulator" will be useful for import into a MS-Excel spreadsheet).

Coordinate system:
Select one of the coordinate systems from the drop-down box "Coordinate system:". The exported

coordinates will be transformed into the selected coordinate system.
Note: The available coordinate systems depend on the tiepointlist you want to export.

Default file name extension:
This extension will be added automatically to the filename if not extension is given (default: ".csv").

Header format:
You can decide between three header formats:
none - no header will be exported
just titles - only the column titles will be exported (e.g. "Name, X, Y, Z")
full - the column titles and some other useful data will be exported (e.g. date/time exported, name of the project & tiepointlist)

Comment tag:
This character (or even characters) will be placed before the header in order to mark it as "no data".

After all settings are made it is possible to save the settings. This provides faster export by just selecting one of the pre-defined format settings from the drop-down list on the top of the dialog. To save the settings click on the button with the plus ("+") on it. You will be prompted for a name. Enter the name (Info: Adding "Default" to one of the names will cause RiSCAN PRO to use this pre-defined format settings as default) and click on "OK" .
Wrong, or out of date pre-defined format settings can be deleted by selecting them one by one from the drop-down-list and clicking on the button with the minus on it.

To finally export the tiepointlist click on the button "OK" on the bottom of the dialog.

- *Import*

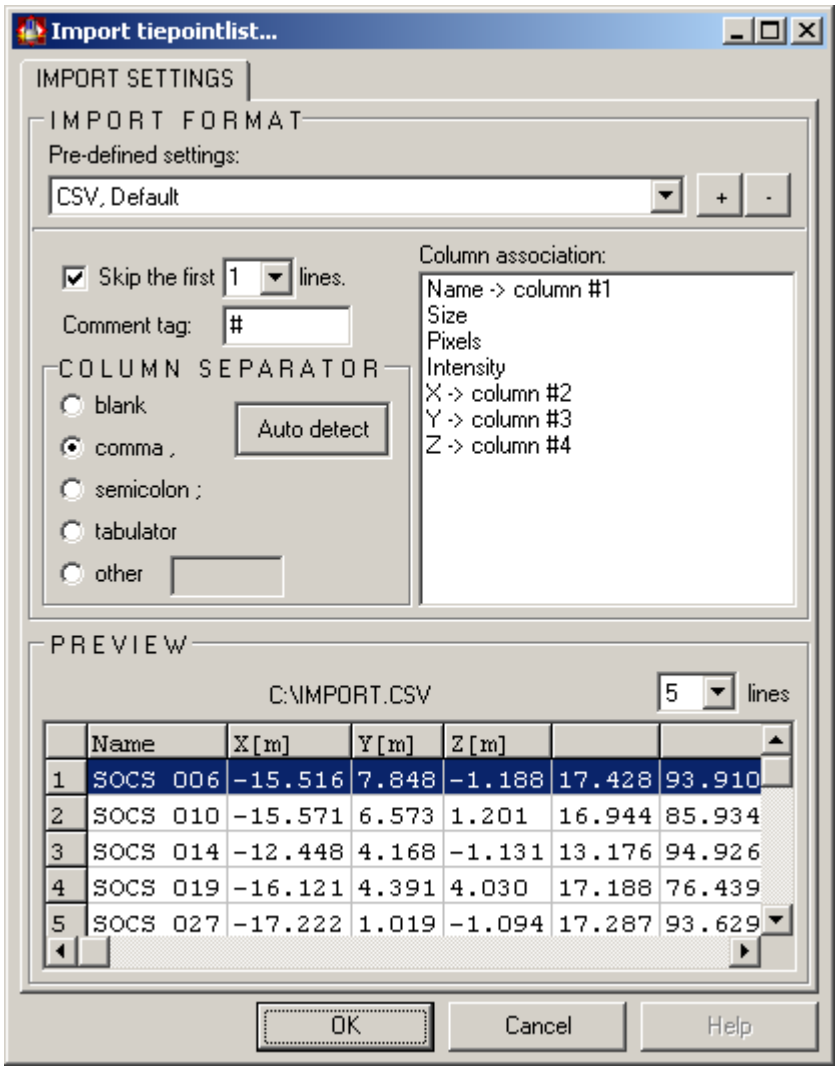
Imports tiepoints from several external data formats.

Supported data formats are:

- *.psi (raw data from totalstations)
- *.or (Application "Caddy")

and also any ASCII (= text) file such as .CSV (comma separated values) files.

When selecting the import function you will be prompted to insert the file you wish to import. If you insert .gis or a .kor file the points will be imported without any dialog otherwise the following dialog will appear:



This dialog allows to import a lot of different formatted data files.

The settings you have to make in order to import tiepoints are:

Skip lines (optional):
This causes the import function to ignore the first n lines from the file (e.g. this is just a comment or anything else...).

Comment tag (optional):
Lines beginning with that character(s) will be ignored

Column separator:
You have to set the column separator to the correct character in order to recognize the data columns from the file.
Normally this is the comma (","). If you don't know the column separator you can try to click on the button "Auto detect". This function attempts to find the correct character. Note, that this function may get wrong results in very "noisy" files.
You can check the right setting of the column separator in the preview located on the bottom of the dialog.

Column association:
After the column separator was set and you got a correct preview you can associate the columns. This is needed in order to tell RiSCAN PRO which column of the file contains which data of the tiepoint. Just drag the column from the list-box showing all columns and drop it on the corresponding column of the preview.

After all settings are made it is possible to save the settings. This provides faster import by just selecting one of the pre-defined format settings from the drop-down list on the top of the dialog. To save the settings click on the button with the plus ("+") on it. You will be prompted for a name. Enter the name (Info: Adding "Default" to one of the names will cause RiSCAN PRO to use this pre-defined format settings as default) and click on "OK" .
Wrong, or out of date pre-defined format settings can be deleted by selecting them one by one from the drop-down-list and clicking on the button with the minus on it.

To finally import the tiepoints into the tiepointlist click on the button "OK" on the bottom of the dialog.

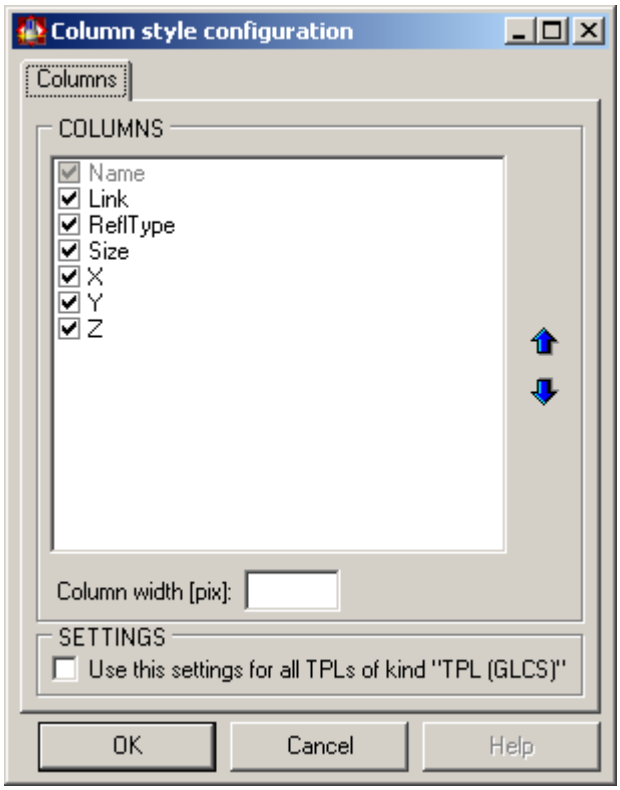
After importing points into a TPL PRCS you will be asked if these points are controlpoints (see "Set controlpoint state 78").

- *Reload*

  This reloads the tiepoint list. This refreshes the display and also recalculates the deviations (only in a TPL SOCS).

- *Layout*

  You can select which columns should be displayed in which order.
  When selecting this menu item the following dialog appears:



Just check or uncheck the columns you want to display or hide (by clicking with the left mouse-button

into the box in front of the column name. You can change the order of columns by dragging a certain column and dragging it over the place where it should be. As an alternative you can select the column an push on of the arrow buttons on the right side of the dialog.
You can also change the size of each column. Just select one of the columns and resize it by editing the width in the "Column width [pix]" box.

By clicking on the button OK the settings will be applied, but only for the current tiepointlist until RiSCAN PRO is closed. If you want to save the configuration permanent and for all tiepointlists of this type you have to check "Use these settings for all TPLs of kind "..." ".

Note: The first column (normally this is "Name") can NOT be moved or deactivated.

- **Menu "Tiepoint"**
  - *New*

    see "Add a new tiepoint 78".
  - *Edit*

    see "Edit TP 78"
  - *Set reflector type*

    Selecting this function allows you to set the reflector calibration. See also "Add a new tiepoint 78".
  - *Delete all / selected tiepoints*

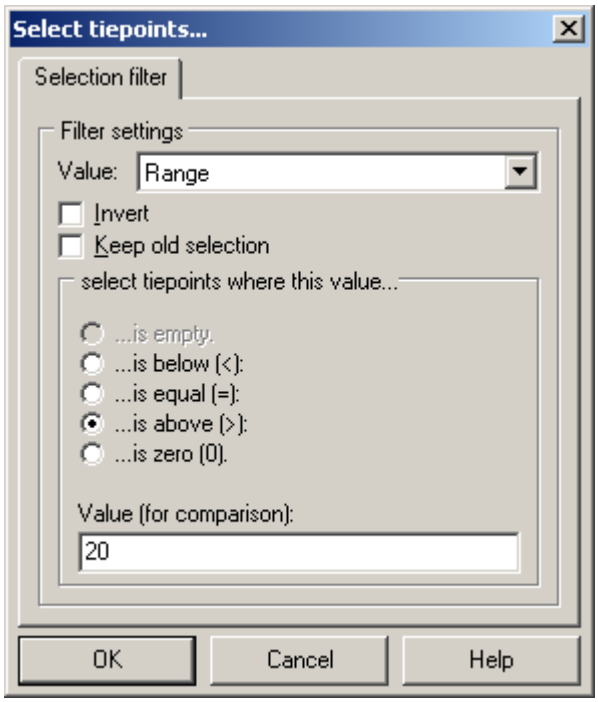
    Use these functions to delete the selected tiepoints or all tiepoints of the tiepointlist (You can not undo this function).
  - *Copy tiepoints to...*

    This copies the selected tiepoints to the selected destination TPL. The coordinates of the tiepoints will be transformed by using the SOPs and the POP between the source and the destination TPL. The copied tiepoints are automatically linked with their originals.
  - *Calc X, Y, Z from linked TP*

    This causes RiSCAN PRO to recalculate the coordinates of the selected tiepoint by taking the linked tiepoint and transforming it into the coordinate system of the local tiepoint.
  - *Select all / invert / no*

    With these functions you can quickly select all tiepoints, no tiepoint or invert the tiepoint selection.
  - *Select tiepoints...*

    This is a tiny tool to select all tiepoints matching a given criteria:



To use this tool just select a value (column) and the criteria (above, below, equal to,... this value).

When "Invert" is checked the result of the filter tool is inverted.

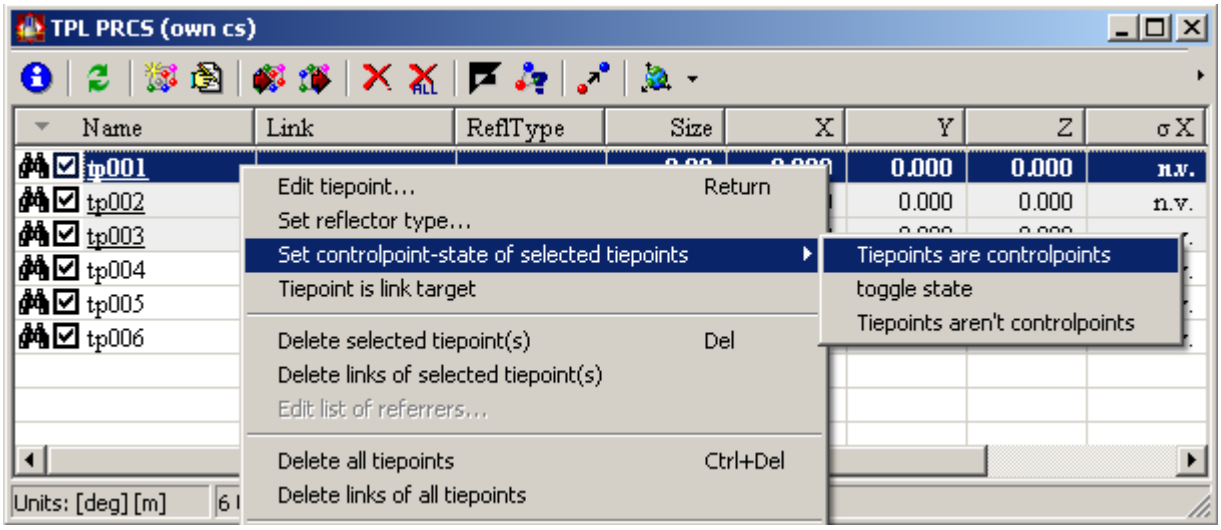
When "Keep old selection" is selected all tiepoints selected before using this tool are also selected after using it (works like an OR-filter).
So you can realize a "multiple" selection by running these tools with different settings but "Keep old selection" checked.

- *Find corresponding tiepoints (only available in TPL SOCS)*

  see "Registration via tiepoints 125"

- *Set controlpoint state (only available in TPL PRCS)*

  Use this menu entry to determine if the tiepoint is a controlpoint or not.



In this example tiepoints "tp001", "tp002" and "tp003" are controlpoints (underlined and light gray background color) while "tp004", "tp005", and "tp006" are "normal" tiepoints.

- **Menu "Tiepoint-scan"** (only available in TPL SOCS)
  - *Fine scan selected tiepoints*

    Use this to make tiepointscans 90 of all selected tiepoints.
    The scanner will automatically fine scan all selected tiepoints. After this process the coordinates of the tiepoints are overwritten by the new (=more precise) coordinates of the fine scanned tiepoints.

    Note:
    The tiepoints will automatically be sorted by phi before they are scanned in order to make this procedure faster (The scanning order is not the order the tiepoints are displayed).

  - *Recalculate tiepoint positions*

    This searches the reflector positions of existing tiepointscans and sets the coordinates of the corresponding tiepoints.

    All listed tiepoints
    All tiepoints of the tiepointlist will be treated this way.

    selected tiepoints
    Only selected tiepoints of the tiepointlist will be treated this way.

    from finescans (not listed tiepoints)
    You can use this function to restore tiepoints from existing tiepointscans.

- **Menu "View Tiepoints"**
  - *Show linked tiepoint*
    This opens the tiepointlist of the linked tiepoint and selects the linked tiepoint.
  - *Show additional information*
    This switches on/off the additional information 78

- *View all / select / invert / no*
  these functions set the visibility of each tiepoint (Only tiepoints with the black binoculars in front of the tiepoint name in the tiepointlist will be displayed in a 2D or 3D-view).

- **Menu "Combined adjustment"**

  - *Use this tiepointlist*

    This switches the usage of the tiepointlist for the combined adjustment on or off.
    With "Use this tiepointlist" you can switch on/off the usage for all tiepoints in this tiepointlist without changing the real switch status (the checkboxes before the tiepoints will be grayed - disabled - but not unchecked).

  - *Use all / selected / invert*

    This switches the usage of the tiepoints for the combined adjustment on or off.

4.4 Tiepoint scans

In order to determine the exact position of a reflector, you can use a "Tiepointscan 90" or a "Fine-scan".

via Scan

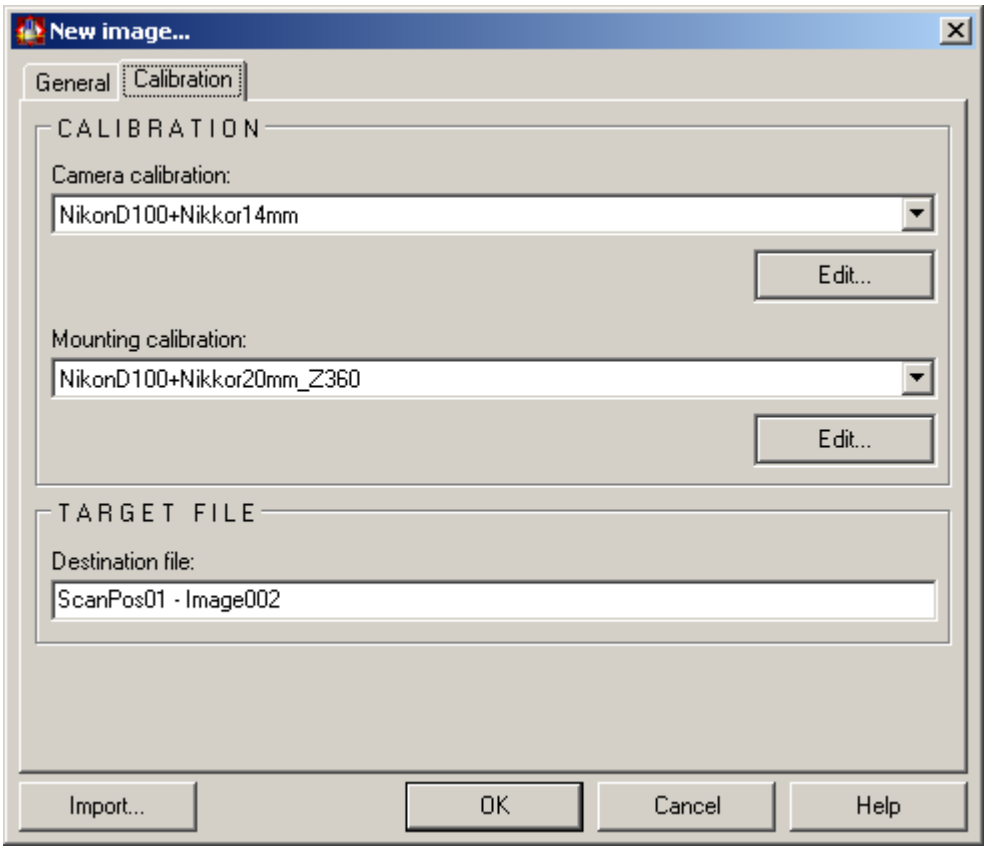
1. Make an Overviewscan 69
2. Extract reflectors see "Reflector extraction 73"
3. Make finescan(s) The tiepointlist window 78

via Image

This procedure provides a very fast and convenient way to determine the position of a tiepoint.

Adapt the mounting and camera 37 calibration settings.

Right-click on the directory "SCANPOSIMAGES" from the scan position and select "New Single Image..." from the menu.



Sheet "General"

- *Description*

  Provide additional information (optional)

Sheet "Calibration"

CALIBRATION

- *Camera Calibration*

  select the desired camera calibration settings. You can change the settings by clicking on the "Edit..." Button (see Camera Model 37).

- *Mounting Calibration*

  select the desired mounting calibration settings. You can change the settings by clicking on the "Edit..." Button (see Mounting Calibration).

TARGET FILE

- *Destination File*

  Provide a name for the new image.

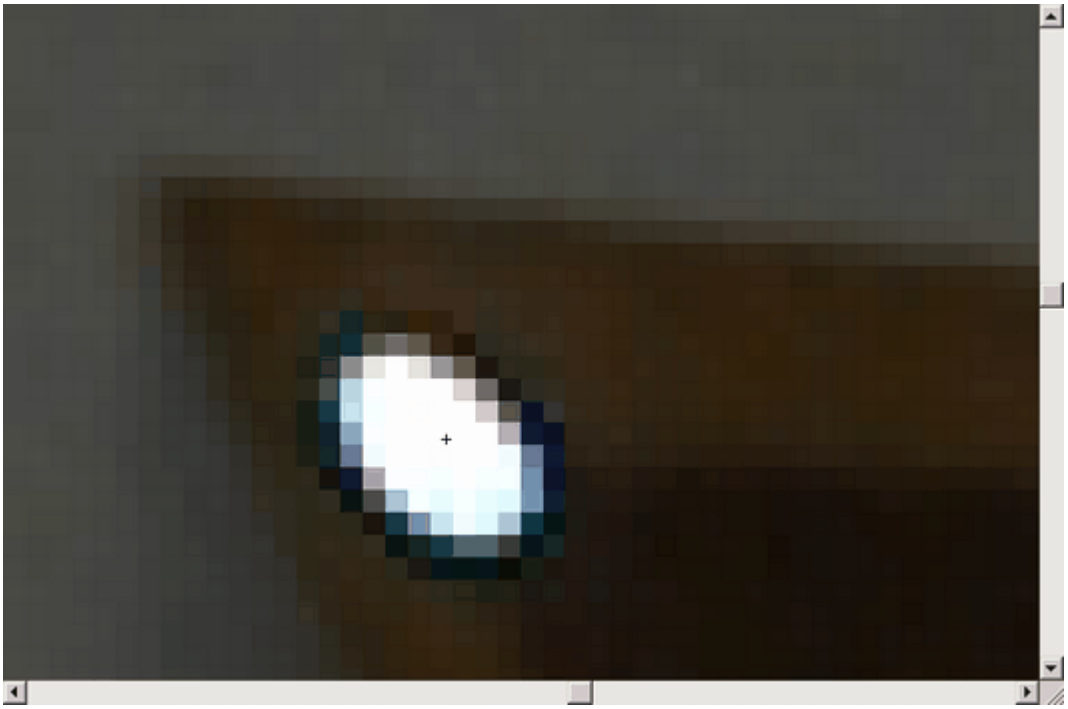
You can import an image by clicking on the "Import..." Button (not recommended for this purpose).

Click "OK" to confirm the settings and create the image. The output will be stored in the directory "SCANPOSIMAGES".

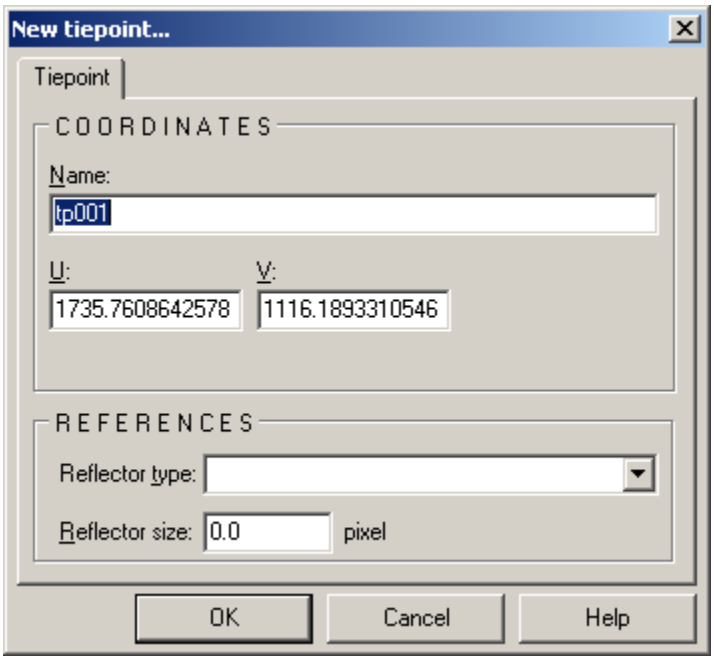
Adding Tiepoints

Open the image from the directory "SCANPOSIMAGES" by double-clicking it.

- select the desired tiepoint(s) in the image and click the left button of your mouse to set a marker (place it in the center of the tiepoint). This will position a "+"-symbol at the coordinates where you have clicked the button.



- right-click on the created marker and choose "Add point to TPL" from the menu (or "Delete marker" if you choose not to add the marker).



COORDINATES

- *Name*

  select a name for the tiepoint

- *U and V*

  these are the precise coordinates of the marker and should not be altered

References

- *Reflector type*

  select the proper calibration settings for the reflector

- *Reflector size*

  enter the approximate size of the reflector in pixel.

Confirm the settings by clicking "OK".

Open the tiepointlist by double-clicking on the TPL (image) of the image ("SCANS" -> ScanPosXX -> "SCANPOSIMAGES" -> ImageXXX)

Select the desired tiepoints and click the "Finescan" button from the menu ( ) to start the fine-scanning process. The output will be saved in the directory "TIEPOINTSCANS" and the tiepoints will be added to the TPL SOCS.

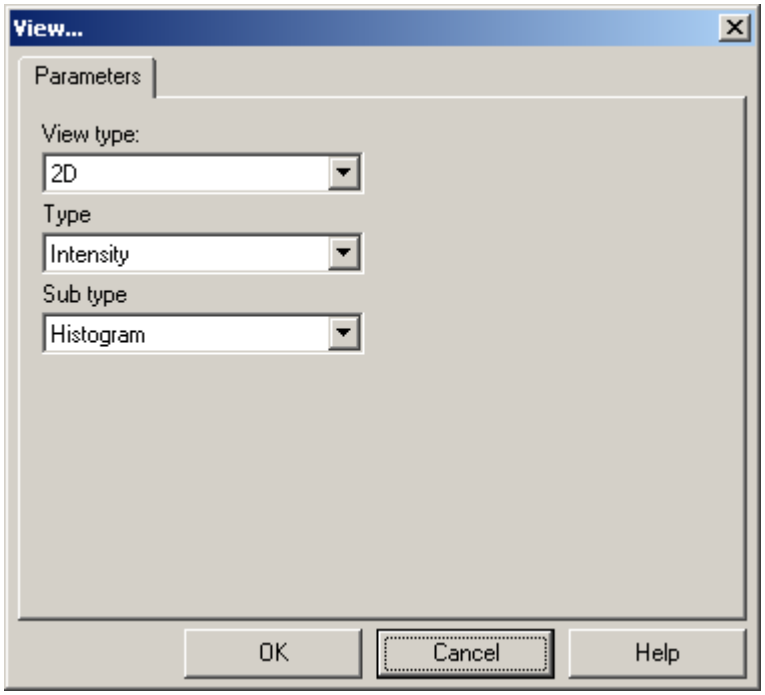
Part V

Data visualisation

5 Data visualisation

RiSCAN PRO can display the acquired data (scans, polydata, images) in either a 2D view 96 or a 3D view 102.

To open a view just double click on an item in the project manager (or click with right mouse button on the item and select "View...").
If the selected item is a **scan** or a **polydata** this will show the following viewtype selection dialog:



For a description of the viewtypes see "Viewtypes 95".

If you have selected an **image** or an **orthophoto**, no viewtype selection dialog will appear and the 2D view will be opened instead.

5.1 Viewtypes

Following viewtypes are available for 2D and 3D:

Type	Sub type	View		Data loaded			Comment
		2D	3D	XYZ	INT	RGB	
Intensity	Direct	X	X	X	X		Point color is determined via intensity (black = no intensity, white = full intensity)
	Histogram	X	X	X	X		Similar to "Intensity direct" but a histogram is used to scale the intensity of each point in order to get a better contrast. The scale factor for the intensity is determined by counting the points having a the same intensity. The more points the higher the scale factor will be
	Scaled	X	X	X	X		Point color is linear scaled between two user defined colors according to the point intensity
	Simple	X			X		Similar to "Intensity direct" but no point coordinates are loaded (less memory consumption but no coordinate readout possible!)
Reflectivity	Direct	X		X	X		Point color is determined via reflectivity (range corrected intensity, black = no reflectivity, white = full reflectivity)
	Histogram	X					not implemented
	Scaled	X					not implemented
Falsecolor	Height	X	X	X			Point color is calculated based on the height of the point above the X-Y plane of PRCS
	Height Intensity	X	X	X	X		Similar to "Falsecolor - Height" but with influence of the intensity
	Range	X	X	X			Point color is calculated based on the distance between point and origin of the coordinate system
	Range Intensity	X	X	X	X		Similar to "Falsecolor - Range" but with influence of the intensity
Simple	Simple		X	X			Only point coordinates will be loaded (less memory consumption but all points will be colored with the same color).
Truecolor	Linearscaled	X	X	X		X	The point color is taken from the true color channel of the data file (gained by the instrument or generated by "color from images")

Note: Not all viewtypes are supported by both the 2D and the 3D view.

5.2 2D view

The 2D view is able to display following objects:

- **Scans (3DD files)**
  In the 2D visualisation 97 the angular data (polar 203 and azimuth 203 scan angles) is neglected and the measurements are put in a plane rasterisation of the image according to the indices within a 3DD data set. The pixel color may be determined by range, height, intensity, or true color.

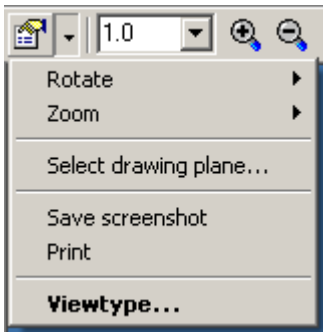
- **Images**
- **Orthophotos**
  Orthophotos generated by RiSCAN PRO 165 or the CityGRID Ortho 168

5.2.1 General

The toolbar of the 2D view:

Items of the toolbar described from left to right:

- **Properties menu**



Rotate

Use this menu to rotate the image/scan 90 deg left or right

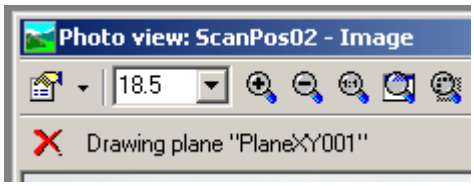
Zoom

This offers to zoom in and out.
Increase / Decrease zoom-sensitivity changes the zoom-sensitivity for dynamically zoom by 10 percent-steps. The value of the zoom-sensitivity can be between 10% - 300%. Keep in mind that a value of 100% will double the size of the image!

Select drawing plane... *(This function is only available for images)*

Use this function to define a drawing plane.
When a drawing plane is defined, you can readout 3D coordinates while you move the mouse over the image. The 3D coordinates are calculated as intersection between the current ray of sight (current mouse position) and the defined plane. These coordinates are displayed in the datareadout window 118 as usual.

You can also drag & drop a plane from the project manager onto the image window in order to define a drawing plane.
To switch back to default mode (undefined the drawing plane) click on the button "Remove drawing plane" in front of the name of the drawing plane in the tool bar of the view window:



Save screenshot

Use this function to save the current scan/image to a file

Print

Use this function to print the image/scan

Viewtype...

This will open the viewtype property sheet. (see Data visualisation: Viewtypes 95)

- **Fast switching to 3D View** (only applicable on scans)

  This will open a new object view and display the scan in 3D. The 2D view will not be closed!

- **Zoom factor**

  Use this list to zoom to predefined zoom-factors.

- **Zoom in**

  zoom in by one sensitivity unit

- **Zoom out**

  zoom out by one sensitivity unit

- **Zoom 100%**

  Sets the zoom-factor to 100% (1:1). This means that one pixel of the image (one measurement of the scan) is represented by one pixel on the screen.

- **Zoom to window size**

  Sets the zoom-factor in order to fit the image into the window size.

- **Zoom to selection**

  Zooms to the last rectangle-selection 100. If there is no selection it will zoom to window size.

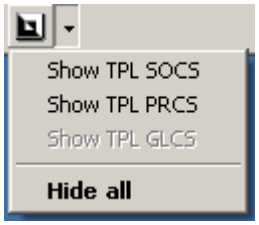
- **Rotate counterclockwise**

  Rotates the image 90° counterclockwise. (only the view; this is not saved to the image file!)

- **Rotate clockwise**

  Rotates the image 90° clockwise. (only the view; this is not saved to the image file!)

- **Show reflectors**



Use this menu to switch on/off the display of tiepoints of a certain tiepoint list.
If a "Show TPL xxxx" is grayed then there are no tiepoints in this tiepointlist or this tiepointlist is not available for this view.

"Hide all" hides (switches off) all shown tiepoints.

To link two tiepoints together you can select them (see mouse-actions 100) right click anywhere in the image and select "Link tiepoints together" from the menu.

Definition of tiepoints:

Within the 2D view you can also add a tiepoint to either the TPL IMAGE (when an image is opened) or the TPL SOCS (when a scan is opened). To do so click with the left mouse button somewhere in the view. This will set a marker. Click with the right mouse button on this marker and select "Add point to TPL" from the menu. The corresponding dialog appears (see Tiepointlist window 78).

5.2.2 Navigation

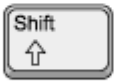
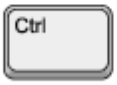
Actions with left mouse button:

Action	Key	Mouseaction	Comment
Set a new marker		click	
Move a marker		hold + move	
Select/deselect a marker	Shift ⇧	click	Also for tiepoint
Delete a marker	Ctrl	click	Also for tiepoint and rectangle selection
Make rectangle selection	Alt	hold + move	
Select markers with a rectangle selection	Shift ⇧	hold + move	Also for tiepoints

Middle mouse button and mouse wheel:

Action	Key	Mouseaction	Comment
Pan		hold + move	 Only if enlarged
Zoom in/out (fixed)		spin mouse wheel up/down	
Increase/decrease zoom sensitivity		spin mouse wheel up/down	
Increase/decrease intensity		spin mouse wheel up/down	

Actions with right mouse button:

Action	Key	Mouseaction	Comment
Zoom in/out		hold + move up/down	
Zoom in (fixed)		click	
Zoom out (fixed)		click	
Show menu		click	Click on a marker/tiepoint for special menu

"Zoom in/out (fixed)" means, that the image/scan is scrolled depending on the zoom factor and direction. So the point witch was under the mouse-cursor before zooming will be under the mouse-cursor again after zooming. This makes zooming more comfortable and orientation easier.

Note: Tiepoints can **NOT** be moved or deleted like normal markers, use the tiepoint menu instead!

5.3 3D view

In the 3D view the complete geometrical information is used. As a 3DD data set basically represents a point cloud, every measurement is represented as a point in 3D space. The color of the point for visualisation may again be chosen to represent range, height, intensity or similar.

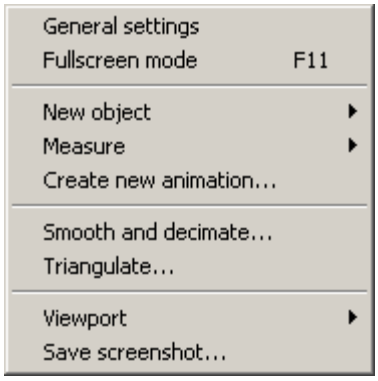
5.3.1 Object view

The object view provides a way to visualize several different objects (e.g. scan, polydata, ...). For more information which objects could be displayed see the "Object inspector 108". To create a new object view right-click on the directory "VIEWS" in the project manager and select "New object view..." from the menu. This will create a new object within the directory and opens a new window.

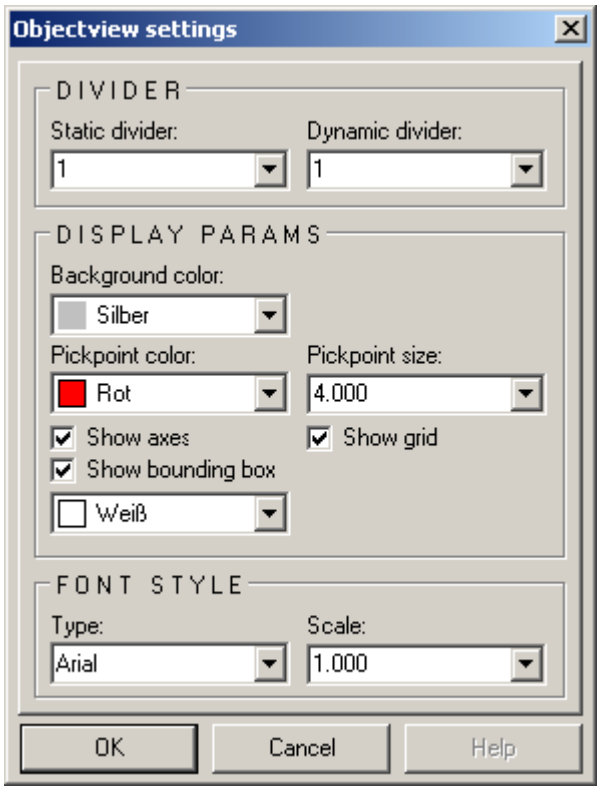
To add some objects, drag and drop them into the object view or into the object inspector 108.
How to navigate within this view see "Navigation 105".

Popup menu:

If you right-click anywhere within an object view, the following popup menu will appear:



General Settings



- **Static divider**
  Is used while not navigating in the 3D scene..

- **Dynamic divider**
  Is used while navigating in the 3D scene (usually set larger than the "static divider").

Note: With "Static divider" and "dynamic divider" you can reduce the number of points/triangles displayed. This makes navigation easier.

- **Background color**
  Set the background color of the object view window.

- **Pickpoint color**
  Set the color for the pickpoint.

- **Pickpoint size**
  Defines pickpoint size (in pixels).

- **Show axes**
  Show/hide axes symbol. For more settings see the program settings 24.

- **Show grid**
  Show/hide grid (only available in orthogonal mode).

- **Show bounding box**
  Show/hide bounding box. You can also select the color of the bounding box.
  The bounding box shows the maximum extensions of all objects.

- **Font type**

Select the font you want to display with the objects, which have a caption.

- **Font scale**
  Select size of font. This value is a factor, that is multiplied with a default size.

Fullscreen mode (Shortcut: "F11")

You can switch the object view to fullscreen mode. That means the whole screen will be used do display this object view.
To leave the fullscreen mode use the same menu item or press "F11".

Note: Some operations will not be available in fullscreen mode.

New object

See "Data postprocessing: Create geometry objects 170".

Measure

See "Data postprocessing: Measurements 177".

Create new animation

See "Data postprocessing: Animations 184".

Smooth and Decimate...

This function modifies the surface structure of the polydata object by optimizing the point data (smoothing) and reducing the amount of triangles (decimating). See "Data postprocessing: Smooth & Decimate 155".

Triangulate...

See "Data postprocessing: Triangulation of arbitrary point clouds 153".

Viewport

See "Data visualisation: Viewports 118"

Save screenshot...

Saves a screenshot of the current object view (JPEG or BMP).

5.3.2 Navigation

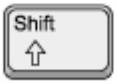
Actions with left mouse button:

Action	Key	Mouseaction	Comment
Set pickpoint		click	
Rotate around pickpoint		hold + move	
Rotate around vertical axis	Ctrl	hold + move left/right	
Rotate around horizontal axis	Shift ⇧	hold + move up/down	
Select object	S	click	The object will be marked in the object inpsector
Set reference point	R	click	Is used in the readout window
Define point coordinates for some operations	Shift ⇧	click	
Set center of camera	C	click	
Show information	I	click	Show some information of the point closest to the line of sight in the info window

Middle mouse button and mouse wheel:

Action	Key	Mouseaction	Comment
Set pickpoint		click	
Perspective: Walk in/out Orthogonal: zoom in/out		spin mouse wheel up/down	Change position of camera Change scene scale of camera
Perspective: Zoom in/out	S	spin mouse wheel up/down	Change scene scale of camera
Pan		hold + move	
Pan along horizontal axis	Ctrl	hold + move left/right	
Pan along vertical axis	Shift ⇧	hold + move up/down	
Increase/decrease point size	P	spin mouse wheel up/down	Changes also the line width
Pitch camera	X	spin mouse wheel up/down	The angle for rotation is defined in program settings
Turn camera	Y	spin mouse wheel up/down	
Roll camera	Z	spin mouse wheel up/down	

Actions with right mouse button:

Action	Key	Mouseaction	Comment
Set pickpoint		click	
Perspective: Walk in/out		hold + move up/down	 Change position
Orthogonal: Zoom in/out		hold + move up/down	 Change scene scale
Roll camera		hold + move left/right	
Rectangle zoom		hold + move	Left to right → Magnification Right to left → View all

Note:
Make sure that the mouse buttons are not exchanged. To check this open the "mouse-settings" dialog and disable "Switch primary and secondary buttons".

Actions with keyboard:

Action	Additional key	Key	Comment
Slide along the horizontal axis		← or →	
Turn around the horizontal axis	Ctrl	← or →	
Slide along the vertical axis		↑ or ↓	
Turn around the vertical axis	Ctrl	↑ or ↓	
Move forward/backward	Shift ⇧	↑ or ↓	
Toggle selection/view mode		Space	
Hold current pickpoint		H	Hold this key pressed during mouse click
Accelerate mouse action (eg. rotation, zoom, ...)		A	Hold this key pressed during mouse action
Slow down mouse action (eg. rotation, zoom, ...)		D	Hold this key pressed during mouse action
Fix dynamic draw mode		Alt	Hold this key pressed

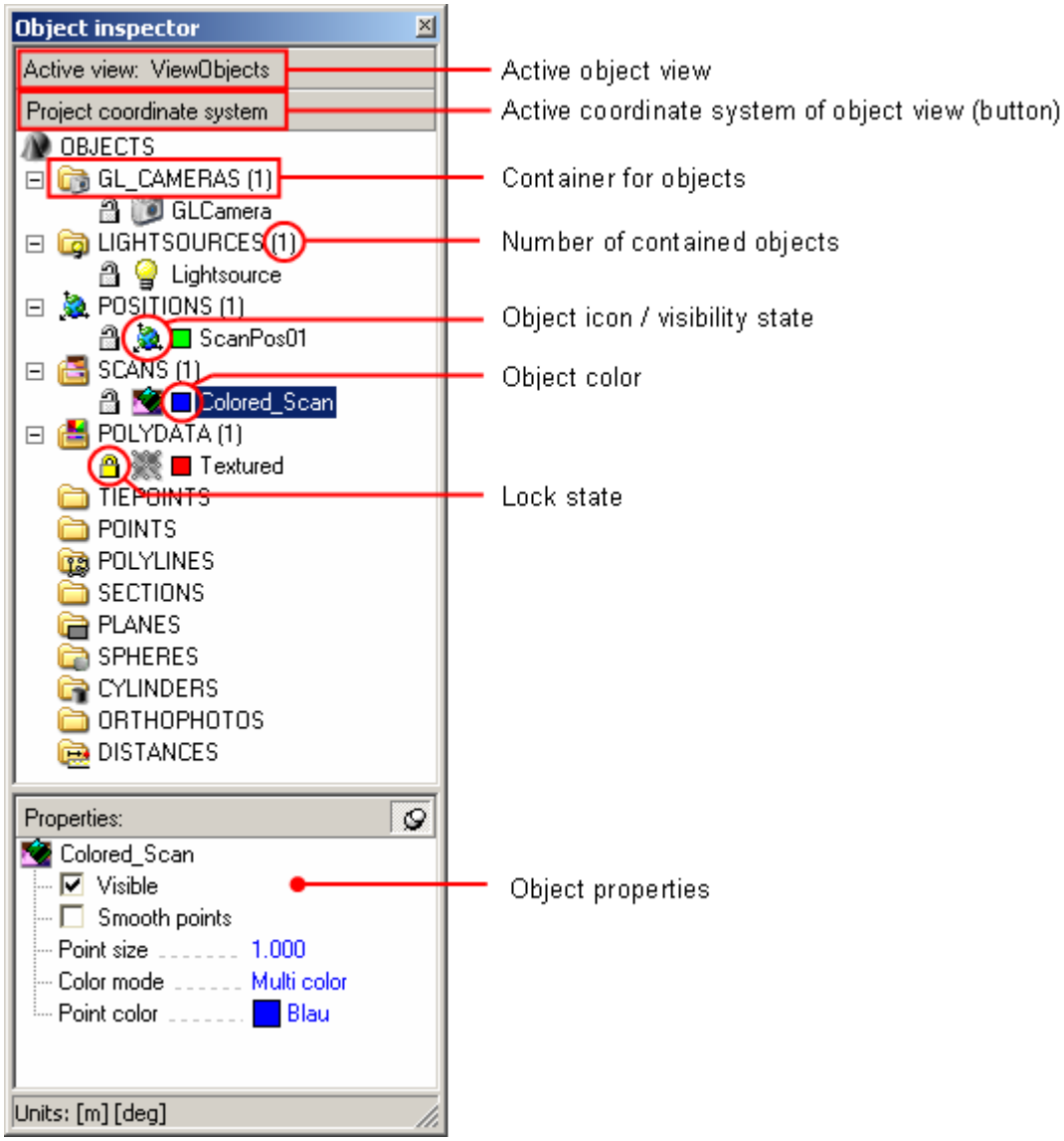
5.3.3 Object inspector

The object inspector is the interface between the objects of a project (e.g. scan, polydata…) and an object view. There is only one object inspector window for the whole program. If the window is visible, it will be activated automatically if an object view gets active. To show the object inspector select "View" -> "Object inspector" from the main menu (or use the shortcut STRG + ALT + O).

With the object inspector you can manage all the objects that are displayed within an object view.
The main features are:

- add objects

- remove objects
- change object properties (visibility, color, …)
- rename object
- locate objects in the project manager



The objects are arranged in special folders (containers), e.g. all scan objects are inserted into the "SCANS" folder. Beside the folder the current amount of contained objects is displayed. To add objects to the active object view, drag and drop them to the object view window or to the object inspector. The new added objects will be inserted into the folder structure.

Coordinate system:

To change the coordinate system click on the button and select either "Scanner coordinate system", "Project coordinate system" or "Global coordinate system". When you select "Scanner coordinate system" you will be prompted to select the scan position of which you want to use the coordinate system. The coordinate system influences the data readout. It is also used when you create a new tiepoint, new sections and for the axes symbol of the object view.

Note:
When you open an object contained in a scan position in an object view the coordinate system will be automatically set to the corresponding coordinate system. Otherwise the coordinate system will be set to PRCS.

Visibility state:
You can change the visibility state of an object by clicking on the object icon or change the "Visible" property. If the object is invisible the icon will be grayed.

Note:
Making the object invisible is not the same as removing it from the view. When you hide an object the object will stay loaded in main memory. This influences the number of objects that can be displayed simultaneous and the time RiSCAN PRO needs to open an view.

Object color:
Some objects have a color property. If a color property is available it is displayed after the object icon. When you click on the color icon you can change between single color mode and multi color mode (only available for scans and polydata objects).

Lock state:
You can change the lock state by clicking on the lock icon. When an object is locked you can not change the properties of this object except the visibility state. It is also impossible to select or delete any data of this object.

Object properties:
Every object has its own properties. These properties are displayed when you select the object. You can also select multiple objects (of same kind) and change their properties at one step.

Following objects are available:

- GLCamera 108
- Light source 108
- Position 108
- Scan 108
- Polydata 108
- Tiepoint 108
- Point 108
- Polyline 108
- Section 108
- Plane 108
- Sphere 108
- Cylinder 108
- Orthophoto 108
- Aerialview 108
- Distance 108

The table below shows the available objects and their properties. Each object type also has a specific context menu (click with right mouse button).

Common menu entries and actions:

- *Expand all*
  Expand tree structure.

- *Show all*
  Make all objects of this container visible.

- *Hide all*
  Hide all objects of this container.

- *Rename…*
  Rename object.

- *Remove*
  Remove object from object view.

- *Locate in "project manager"*
  Locate and select object in project manager.

- Double click on the object icon in order to view the complete object in the center of the screen.

GLCamera object (GL_CAMERAS):

Property	Value	Comment
Camera mode	Perspective Orthogonal	View mode of camera.
Position (X/Y/Z)	Floating point number	Position of camera.
Direction (X/Y/Z)	Floating point number	Direction vector of camera (unit vector).
Up (X/Y/Z)	Floating point number	Up vector of camera (unit vector).
Scene scale	Floating point number	Scale factor for linear zooming.
Focal length	Floating point number	Focal length of camera (mm).
Near plane	Floating point number	Near clipping plane of camera (read only).
Far plane	Floating point number	Far clipping plane of camera (read only).

Light source object (LIGHTSOURCES):

Property	Value	Comment
Shining	Yes No	Turn on/off light source.

Position object (POSITIONS):

Property	Value	Comment
Visible	Yes No	Show/hide position object.
Show caption	Yes No	Show/hide position name.
Color	Color	Color of position object.

- *Modify SOP…*
  Change position and orientation of position. See "Data registration: Manual coarse registration 131"

- *Corresponding objects*
  You can perform some actions on the objects that belong to this position and which are also part of the same object view.

Scan object (SCANS):

Property	Value	Comment
Visible	Yes No	Show/hide scan object.
Smooth points	Yes No	Paint round points (looks better, but needs more time for drawing).
Point size	Integer between 1 and 20	Size of points in pixel.
Color mode	Multi color Single color	
Point color	Color	Point color of scan object.

- *Change view-type…*
  Change current view-type of scan object. See "Data visualisation: Viewtypes 95"

- *Show as 2D*
  Open scan object in 2D window. The 3D view will not be closed.

- *View*
  You can set default views (such as Bird's eye view, Bottom view and so on), which only use the bounding box of the object. Thus you will not see the complete scene but only the selected object.

Polydata object (POLYDATA):

Property	Value	Comment
Visible	Yes No	Show/hide polydata object.
For point cloud:		
Visible	Yes No	Show/hide point cloud.
Smooth points	Yes No	Paint round points (looks better, but needs more time for drawing).
Color mode	Multi color Single color	In multi color mode the selected viewtype is used for coloring.
Point color	Color	This color is used in single color mode.
Point size	Integer between 1 and 20	Size of points in pixel.
For triangulated surface:		
Visible	Yes No	Show/hide triangulated surface.
Smooth points	Yes No	Paint round points (looks better, but needs more time for drawing).
Color mode	Multi color Single color	In multi color mode the selected viewtype is used for coloring.
Polygon color	Color	This color is used in single color mode.
Point size	Integer between 1 and 20	Size of points in pixel, used in point mode.
Line width	Integer between 1 and 20	Width of line in pixel, used in wireframe mode.
Static	Polygon smooth Polygon flat Wireframe Points	Defines the static draw mode. Use polygon draw mode to paint as closed surface. For faster drawing use the point draw mode.
Dynamic	Polygon smooth Polygon flat Wireframe Points	Defines the dynamic draw mode. Use polygon draw mode to paint as closed surface. For faster drawing use the point draw mode.
Front face	Real color Single color Cull	Defines how the front face will be displayed.
Back face	Real color Single color Cull	Defines how the back face will be displayed. Select cull mode for faster drawing.
Face color	Color	This color is used in single color mode.
Wireframe overlay	None Static Dynamic Static & Dynamic	Select in which draw state the wireframe overlay should be used.
Wireframe color	Color	This color is used for the wireframe overlay.
Full wireframe overlay	Yes No	Select if also hidden parts should be overlayed.

- *Change view-type…*
  Change current view-type of polydata object. See "Data visualisation: Viewtypes 95"

- *View*
  You can set default views (such as Bird's eye view, Bottom view and so on), which only use the bounding box of the object. Thus you will not see the complete scene but only the selected object.

Tiepoint object (TIEPOINTS):

Property	Value	Comment
Visible	Yes No	Show/hide tiepoint object.
Show caption	Yes No	Show/hide tiepoint name.
Draw mode	Point Reflector type	Draw mode for tiepoint object.
Point size	Integer between 1 and 20	Size of point in pixel. Is used in point draw mode.
Color	Color	Color of tiepoint object.

Point object (POINTS):

Property	Value	Comment
Visible	Yes No	Show/hide point object.
Position (X/Y/Z)	Floating point number	Position of point object.
Size	Integer between 1 and 20	Size of point in pixel.
Color	Color	Color of point object.

Polyline object (POLYLINES):

Property	Value	Comment
Visible	Yes No	Show/hide polyline object.
Line width	Integer between 1 and 20	Width of line in pixel.
Node size	Integer between 1 and 20	Size of nodes in pixel.
Polyline color	Color	Color of polyline object.
Node color	Color	Color of polyline nodes.
Show nodes	Yes No	Show/hide polyline nodes.

- *View*
  You can set default views (such as Bird's eye view, Bottom view and so on), which only use the bounding box of the object. Thus you will not see the complete scene but only the selected object.

Section object (SECTIONS):

Property	Value	Comment
Visible	Yes No	Show/hide section object.
Draw mode	Line Points	Draw mode for section object.
Size	Integer between 1 and 20	Size of section in pixel.
Color	Color	Color of section object.

- *View*
  You can set default views (such as Bird's eye view, Bottom view and so on), which only use the bounding box of the object. Thus you will not see the complete scene but only the selected object.

Plane object (PLANES):

Property	Value	Comment
Visible	Yes No	Show/hide plane object.
Surface color	Color	Color of plane object.
Origin (X/Y/Z)	Floating point number	Position of plane object.
Direction (X/Y/Z)	Floating point number	Direction vector of plane object (unit vector).
Up (X/Y/Z)	Floating point number	Up vector of plane object (unit vector).
Width	Floating point number	Width of plane object.
Height	Floating point number	Height of plane object.
Draw mode	Fill Raster Border	Draw mode of plane object.

- *Modify…*
  Change position and orientation of plane object. This is described in the chapter "Manual coarse registration 131". The same dialog is applicable on planes.

- *Invert plane normal*
  Invert normal vector of the plane object (i.e. rotation of 180° deg).

- *Calculate volume & surface area*
  See "Data postprocessing: Measure volume and surface 180"

- *New orthophoto (CityGrid Ortho)*
  See "Data postprocessing: Create orthophotos: CityGRID Ortho plugin 168"

Sphere object (SPHERES):

Property	Value	Comment
Visible	Yes No	Show/hide sphere object.
Radius	Floating point number	Radius of sphere object.
Position (X/Y/Z)	Floating point number	Position of sphere object.
Surface color	Color	Color of sphere object.

Cylinder object (CYLINDERS):

Property	Value	Comment
Visible	Yes No	Show/hide cylinder object.
Height	Floating point number	Height of cylinder object.
Radius	Floating point number	Radius of cylinder object.
Position (X/Y/Z)	Floating point number	Position of sphere object.
Up (X/Y/Z)	Floating point number	Up vector of cylinder object (unit vector).
Surface color	Color	Color of cylinder object.

Orthophoto object (ORTHOPHOTOS):

Property	Value	Comment
Visible	Yes No	Show/hide orthophoto object.
Draw style	Plane Points	Draw mode of orthophoto object.
Point size	Integer between 1 and 20	Size of points in pixel. Is used in point draw mode.

Aerialview object (ORTHOPHOTOS):

Property	Value	Comment
Visible	Yes No	Show/hide aerialview object.
Origin (X/Y/Z)	Floating point number	Position of aerialview object.
Direction (X/Y/Z)	Floating point number	Direction vector of aerialview object (unit vector).
Up (X/Y/Z)	Floating point number	Up vector of aerialview object (unit vector).
Width	Floating point number	Width of aerialview object (read only).
Height	Floating point number	Height of aerialview object (read only).
Back face	Image Cull	Back face draw mode.
Interpolation	Yes No	The image will be interpolated.

- *Modify…*
  Change position and orientation of aerialview object. This is described in the chapter "Manual coarse registration 131". The same dialog is applicable on aerial views.

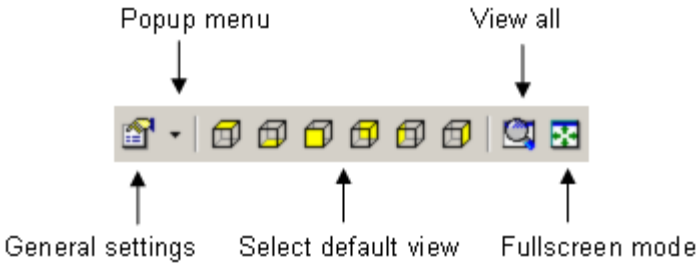
Distance object (DISTANCES):

Property	Value	Comment
Visible	Yes No	Show/hide distance object.
Start point (X/Y/Z)	Floating point number	First point of distance.
End point (X/Y/Z)	Floating point number	Second point of distance.
Line width	Integer between 1 and 20	Width of line in pixel.
Point size	Integer between 1 and 20	Size of points in pixel.
Line color	Color	Color of distance object.
Point color	Color	Color of points.

Note:
Distance objects can only be created in an object view.
You can also display them only in that object view.

5.3.4 Toolbars

3D - Control



- **General settings** - Opens the general settings dialog. For more information see "Object view 102".
- **Popup menu** - Shows the popup menu.
- **Select default view** - Select one of the default views

View	View plane	Direction	Up
Bird's eye view	x-y plane	-z vector	+y vector
Bottom view	x-y plane	+z vector	-y vector
Front view	y-z plane	-x vector	+z vector
Back view	y-z plane	+x vector	+z vector
Left view	x-z plane	+y vector	+z vector
Right view	x-z plane	-y vector	+z vector

- **View all** - View the whole scene. The orientation of the camera is not changed.
- **Fullscreen mode** - Switch current object view to fullscreen mode.

The other toolbars are described in the corresponding chapters.

5.3.5 Viewports

A viewport is a particular position and orientation within a 3D view such as the standard viewports (Bird's eye view, Bottom view, Front view, Back view, Left view, Right view and Scanner view).

Add a viewport

You can easily save your own viewports in the folder "VIEWPORTS" within the project.
To do so click with the right mouse button into the object view window and select "Viewport -> Save". A window appears which shows a summary of the parameters of the virtual camera. Click on the button "OK" to save the viewport.

Edit a viewport

Double-click the viewport in the project-tree (window project-manager). This will open the viewport-dialog where you can edit the position, orientation, focus and the mode of the viewport.

Load a viewport

To restore a previously saved viewport, click with the right mouse button into an object view and select "Viewport -> Load" from the menu or drag and drop it into an object view. The virtual camera of the view will be set to position saved in the viewport.

5.4 Readout window

- **Readout window**

When a view (2D, 3D, or object view) is opened and you move the mouse-cursor in that view, this window will provide information about the data underneath the current mouse position such as coordinates, intensity, color etc. The style of the readout window may differ between 2D-, 3D- or Object-View window and depends on the available data.

To display the readout window select "View" - "Data readout" from the main menu, press CTRL+Alt+D or press the button "Show Data readout window" from the menu (). It is also possible to display more than one readout window for different coordinate systems. All these readout windows will show the coordinates of the same point but transformed into different coordinate systems.

Possible data sections of the data readout window follow below. Text in brackets describes when the section will be available.

- **Head** *(always visible)*

The head of the readout window displays the name of the view underneath the mouse cursor in the first two lines.

With the lock button (left button) you can lock the data of the readout window (no updates are done when you move the mouse). You can also lock the data by holding down the [CTRL]-key while you move the mouse.

With the copy button (second button from left) you can copy the data of the readout window into the

clipboard (e.g. for further usage in MS Excel).

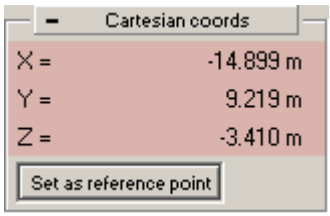
Note:
Only data of visible (expanded) sections will be copied. This gives you the chance to control what data is copied to the clipboard.

With the coordinate system button (the right button) you can modify the coordinate system in which the point coordinates and vectors should be displayed.

Note:
"Scanner coordinate system" (SOCS) is only available when the data was transmitted by either a 2D-View (scan or image) or an object view with a SOCS defined as base coordinate system.

- **Cartesian coordinates** *(2D & 3D scan, object view, 2D image with activated drawing plane)*

  This section shows the cartesian coordinates of the point underneath the mouse cursor in the defined coordinate system (see section "Head 118").
  The button [Set as reference point] enables you to uses the current coordinates for the reference point. This enables the section "Reference point 118".
  You can also define a reference point directly in the view by pressing the key [R] and clicking on the data point.



  Note: Coordinates coming from a 3D view are only coarse coordinates and should not be used for high precision measurement!

- **Polar coordinates** *(everytime cartesian coordinates are available and SOCS is selected)*

  This sections shows the polar coordinates of the current data in the order (Range, Theta, Phi). Theta represents the rotation around the z axis of the scanner.

- **WGS84** *(everytime cartesian coordinate are available and GLCS is selected)*

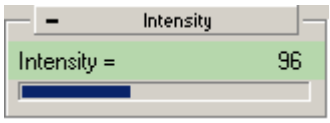
  This sections shows the coordinates as geographical longitude, latitude and height.
  Note: This section is only available when "Global coordinate system" is selected and your used global coordinate system is defined by means of (D)GPS.

- **Frame coords** *(2D scan and image)*

  This section shows the 2D coordinates u and v (column and row) within the 2D view of a scan or an image. u increases from left to right, v increases from top to down.

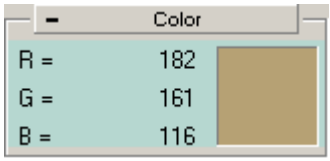
- **Intensity** *(2D scan)*

  This sections shows the intensity of the current measurement. The intensity display can be scaled either from 0..1 or from 0..255 (see chapter "Program settings 24" for details).



The bar on the bottom of the section gives a quick feedback about the intensity of the measurement.

- **Color** *(Any view)*



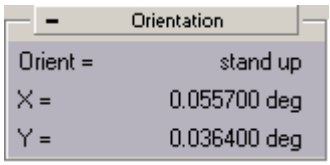
This section shows the components red, green and blue of the color of the pixel underneath the mouse cursor.

- **Timestamp** *(2D scan)*

This section shows the time the measurement was acquired in seconds. The timestamp starts with 0.0 at the first line (smallest phi angle) and increases with increasing phi angle.

- **Orientation** *(2D scan, acquired with an instrument with built-in inclination sensors 71)*

This section shows the coarse alignment of the instrument and the rotation around the X (or Z respectively) and the Y axes.



The line "Orient =" shows the coarse alignment of the instrument. The value may be one of "stand up", "lay back", "top down", "lay front", "unknown". For more details please refer to chapter Inclination sensors 71.

- **Camera center** *(2D image)*

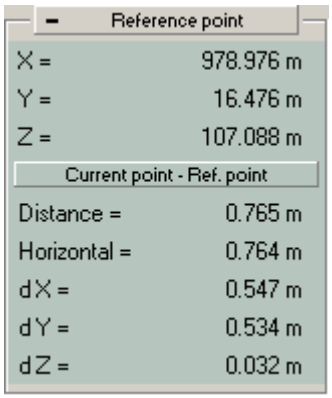
This sections shows the center of the digital camera which has acquired the image.

- **Direction vector** *(2D image)*

This section shows the vector of the ray defined by the mouse. In other words: when you move the mouse over an image you define a direction and the vector of this direction is displayed.

- **Reference point** *(everytime cartesian coordinates are available)*

This sections can be used for quick distance measurements in any view and even between different views.



X, Y, Z are coordinates of the reference point
Distance is the distance between the current point and the reference point
Horizontal is the horizontal part of the distance (in the x-y plane)
dX, dY, dZ are the differences between the current point and reference point in all three coordinate axes

There are two different ways to define a reference point:

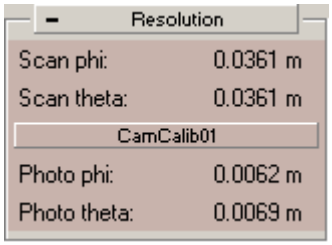
1. Move the mouse over the point of interest.
   Press and hold the [CTRL] key (this will lock the data in the data readout window).
   Press the button [Set as reference point] in the Cartesian coordinates 118 section.

2. Move the mouse over the point of interest.
   Press and hold the [R] key while clicking with the left mouse button on the point.

- **Resolution** *(everytime cartesian coordinates are available)*

This section shows the resolution of the scan (=distance between two measurements) at the distance of the current point. Analog to a scan it will also display the size of a pixel of an image when a default camera calibration is selected.

Everytime new cartesian coordinates are available the scan/photo resolution is calculated from the angular scan/photo resolution and the measurement range.



In the line between scan and photo resolution the name of the default camera calibration (the basis for the calculation of photo phi & theta) is displayed. To change the default camera calibration right click on any camera calibration and select "Default" from the menu.

5.5 Tiepoint display window

The tiepoint display window is a tool window which gives the possibility to manage the tiepointlist and their tiepoints displayed in a 2D view. Thereto this window shows a tree view showing all tiepoints displayed in the currently active 2D view.

To display a tiepointlist in the 2D view you can either use the corresponding menu (see 2D View: General 97) or you just drag the tiepoint list from the project manager and drop it onto the tiepoint display window.

To **show or hide a tiepoint** quickly, click on the magnifier glass in front of the tiepoint.

To **show or hide all tiepoints of a certain tiepoint list**, click on the icon in front of the tiepointlist.

To **remove a tiepoint list** from the 2D view click with the right mouse button onto the tiepoint list in the tiepoint display window and select "Remove" from the menu.

5.6 Image browser window

The image browser window offers a quick way to view thumbnails of all images contained in a project. You can find the image browser in the menu "View" of the RiSCAN PRO main window.

Image type filter

On top of the window you can select which type of images should be displayed: "distorted images", "undistorted

images" or "all images". Distorted images will be displayed in blue color. Undistorted images will be displayed in black color.

Image list & preview

The middle part of the window shows a list of all images grouped by scan positions. The preview will show the thumbnail of the currently selected image.

3D settings

This section only takes affect, when an object view is opened. If an object view is opened and an image is selected in the image browser, the thumbnail of the image is displayed in the 3D view. This is done by drawing four lines representing the field of view of the camera. The length of these lines is set by **Ray length**. The image itself is projected onto a plane which is normal to the center ray of the image. The distance between plane and camera origin can be adjusted with the slider besides "**Show image**". This is a factor from 0% to 100% of "ray length". The four lines can be connected by a **funnel** in order to make the orientation of the image more recognizable.

Part VI

Data registration

6 Data registration

The process of registration of the various scan positions in the PRCS is the determination of the respective SOP matrix. This process is based usually on tiepoints within RiSCAN PRO. Tiepoints are managed by **tiepoint lists** (TPL). Tiepoints are usually defined by retro-reflective targets showing up clearly in the intensity data of the scan data and which can be accurately localized by the use of total stations. The tiepoint itself is commonly the center of a reflective target.

Every project can hold one tiepoint list in the project coordinate system **TPL (PRCS)**. Usually the data are gained by measuring the position of the tiepoints with a total station or by other means, e.g., DGPS. If the tiepoint coordinates are available in global coordinates, they should be entered into the global tiepoint list, **TPL (GLCS)**, and should be transferred into the TPL (PRCS) by defining an appropriate POP matrix to fulfil the requirement of single precision representation.

In order to register a single scan position into the project coordinate system, a tiepoint list in the SOCS system have to be acquired, which is done by fine-scanning the retro-reflective targets 78 visible from the specific scan position. RiSCAN PRO extracts retro-reflective targets from an so-called overview scan or panorama scan and supports the automatic subsequent sequential fine scan 78 of the targets. Once sufficient tiepoints have been gained the SOP matrix can be determined and the scan data can be transferred into the project coordinate system if desired.

6.1 Registration via tiepoints

How to register a scan position:

1. If available, import the external acquired point data (total station or DGPS) into the TPL PRCS (see "The tiepointlist window / Import" 78) and define the tiepoints as controlpoints (you'll be asked after import).

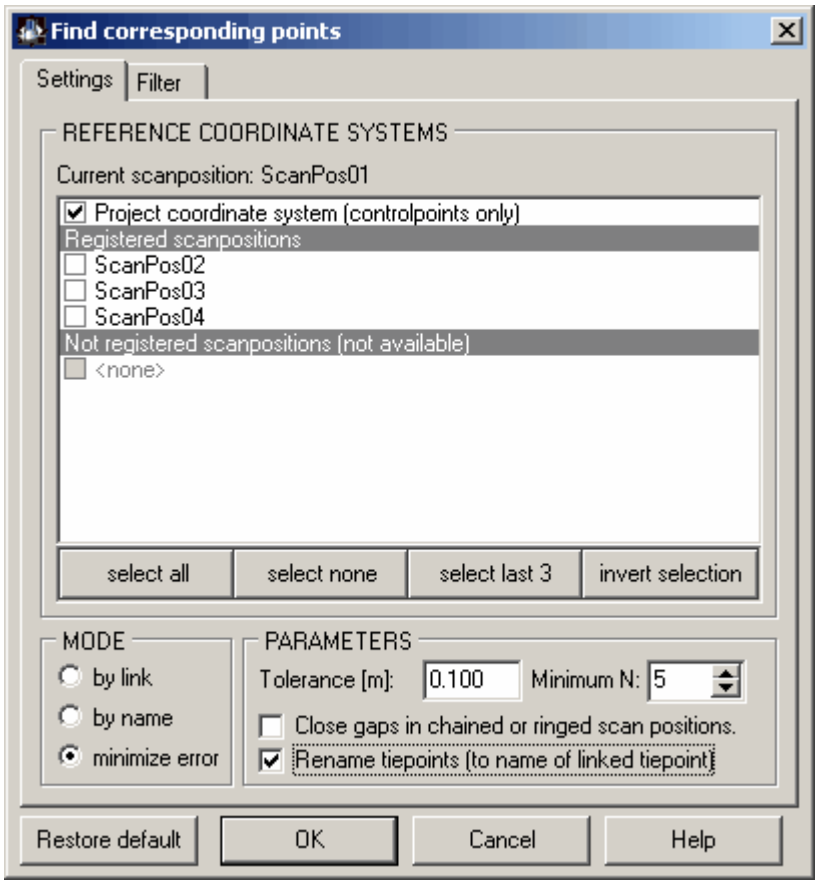
2. Do the reflector extraction and fine scanning for each scan position.

3. No controlpoints available:

   In this case you have to decide which scan position represents your project coordinate system (usually the first). Right click on the desired scan position and select "Registered" from the menu (**Note:** the SOP should be the default matrix and make sure that the TPL PRCS is empty).

4. Open the TPL SOCS of the scan position you want to register.

5. Click on "Find corresponding points..." - the following dialog appears:



REFERENCE COORDINATE SYSTEMS

Select the coordinate systems you want to use to register the scan position.

Select the first item "Project coordinate system" if the TPL PRCS holds controlpoints (default). Additionally you can select one (or even more) of the other (already registered and neighboring) scan positions (this is obligatory if no controlpoints are available).

The algorithm tries to find corresponding points between the current TPL SOCS and the selected coordinate systems. If correspondences between points of different scan positions are found, a new tiepoint in the TPL PRCS is created and all concerned SOCS tiepoints have a link to this PRCS tiepoint. The coordinates of the PRCS tiepoint are calculated (averaged) from all linked SOCS tiepoints.

If the algorithm succeeds, the SOP matrix is calculated from the scan position. If the algorithm fails, no changes are made. Restart the process and try to activate more already registered neighboring scan positions.

MODE

- *by Link*

the SOP will be recalculated without changing the corresponding points (links)

- *by Name*

retrieve the corresponding points by comparing their names (the SOP will be recalculated)

- *minimize error (default)*

  the point-pairs will be detected automatically (the SOP will be recalculated)

PARAMETERS

- *Tolerance*

  defines the search radius (the maximum distance between to corresponding points in order to recognize them as corresponding).

- *Minimum N*

  defines the minimum number of point-pairs. Setting a value can accelerate the calculation and make it more precise. So if you know that there are at least 10 corresponding points, enter 10 into this field (**Note:** If you set this value too high, you might get bad results because points might be linked together that are not related).

- *Close gaps in chained or ringed scan positions*

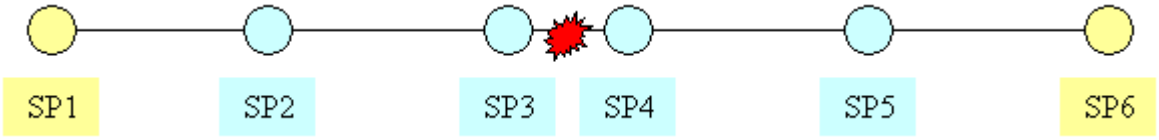
  Activate this option if your scan positions are organized as a ring or a chain.
  In both cases no modification of the SOP matrices is done, only corresponding tiepoints are found in order to create a proper condition for the Hybrid multi station adjustment 141.

- *Rename Tiepoints*

  Selecting this option will rename the tiepoints with the corresponding name of the linked tiepoint

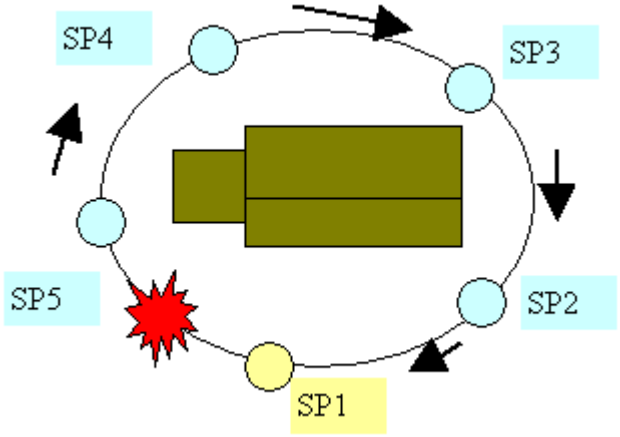
Examples:

- Chain:



  At SP1 and SP6 controlpoints are available. At first SP1 and SP6 will be registered by using the controlpoints.
  Then SP2 is registered onto SP1, SP5 onto SP6, SP3 onto SP2 and finally SP4 onto SP5.
  If you call the Hybrid multi station adjustment 141 now, it's possible that between SP3 and SP4 the deviations are enormous. So it's important to create new tiepoints in order to connect SP3 and SP4.
  To do so run "Find corresponding points" for SP4 again,
  select only SP3 and activate "Close gaps in chained or ringed scan positions".

- Ring:



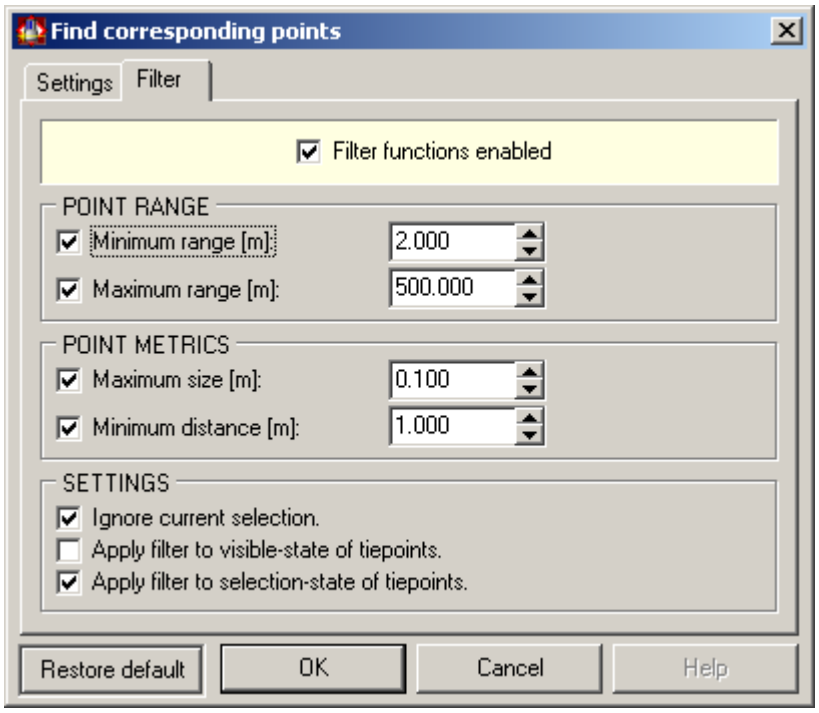
Possibly at scan position SP1 are controlpoints available. Now SP2 is registered onto SP1, SP3 onto SP2, SP4 onto SP3, and SP5 onto SP4. There will by a huge deviation between SP5 and SP1.
If "Find corresponding points" is called for SP5 using SP4 and SP1 it is possible that links between SP5 and SP1 tiepoints are created. But if SP4 is misarrange (related to PRCS) due to the ringed formation it's probable that not all links are found.
And here's the point where the "Close gaps in chained or ringed scan positions" is used.
Run "Find corresponding points" for SP5 again, select SP1 and activate "Close gaps in chained or ringed scan positions".

6. Proceed with step 4 with each scan position you want to register

Possible problems:

- Not enough corresponding points found
  Try to activate more already registered neighboring scan positions. Or acquire more tiepoints (reflector targets).

- The process takes a lot of time and leads to no satisfactory results
  This generally occurs when too many tiepoints are available in the TPL SOCS. Try to reduce the number of tiepoints by either deleting unnecessary tiepoints or just deactivate them (the small hook in front of the name of the tiepoint in the tiepoint list window).
  The deactivation of the tiepoints can be automatically done by RiSCAN PRO. Therefore use the second page of the "Find corresponding tiepoints" dialog called "Filter":



These filter functions allows you to reduce the number of tiepoints by the definition of a range gate ("Minimum range" & "Maximum range"), and the point metrics ("Maximum size" and "Minimum distance").

- *Filter functions enabled*

  Enable the filter functions by activating this checkbox

POINT RANGE

- *Minimum range*

  All tiepoints with a distance lower than this value will be deactivated (default: 2m).

- *Maximum range*

  All tiepoints with a distance higher than this value will be deactivated (default: 30m).

POINT METRICS

- *Maximum size*

  All tiepoints with a size higher than this value will be deactivated (default: 0,3m).

- *Minimum distance*

  Defines the minimal distance between two tiepoints. Tiepoints lying closer together will be deactivated (especially helpful when the data acquisition is done on the street and a lot of car lights are detected as tiepoints).

SETTINGS

- *Ignore current selection*

  Activate this option if the current selection of the tiepoints should be ignored (all tiepoints will be used as input of the filter).

- *Apply filter to visible state of tiepoints*

  This will set the visible states (the magnifying glass in front the tiepoint name) according to the filter output.

- *Apply filter to selection state of tiepoints*

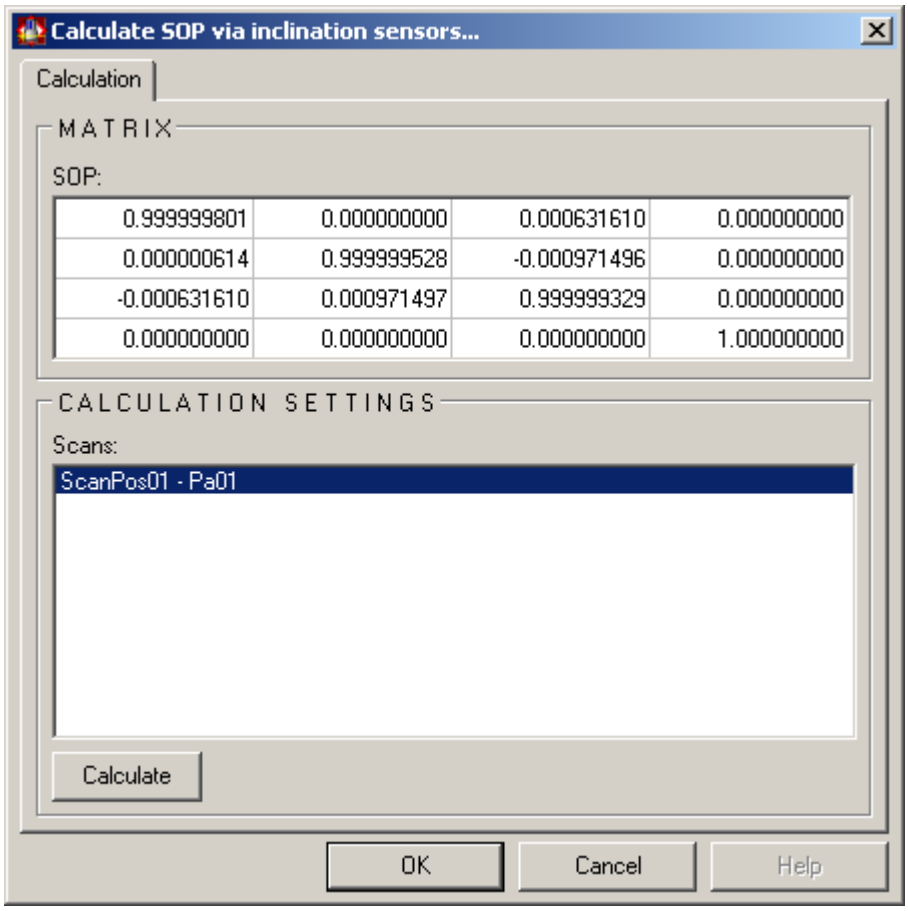
  This will set the selection states (the small hook in front of the tiepoint name) according to the filter output.

6.2 Registration via inclination sensors (optional)

Automatic horizontal alignment of acquired scandata

With RiSCAN PRO you can automatically align the acquired scandata according to the information of the inclination sensors. This is especially helpful, when it's not possible to register the scan position to global coordinate system (gained by totalstation or DGPS). In that case you would set up the scanner at the first scan position, acquire the data, align the data horizontally with this function and register all further scan positions onto this scan position.

You can enter this function by right-clicking on the SOP of a scan position and selecting "Calc via inclination sensors..." from the menu. The following dialog will appear:



The grid on top of the dialog shows the current SOP matrix (normally the identity matrix). On the bottom of the dialog a list displays all scans of the scan position. To calculate the SOP select one scan and click on the button "Calculate". When the analysis of the scan is done the SOP is calculated and displayed in the grid. To finally save the new SOP matrix click on the button "OK".

Usage of inclination values in backsighting orientation

Please refer to chapter "Backsighting 136"

6.3 Manual coarse registration

With RiSCAN PRO you can change the orientation and/or position of a scan position or other objects (e.g. planes, aerialviews) in 3D.

The following step by step description demonstrates the modification of the position and orientation of a scan position. This guide is also applicable on other objects such as planes or aerialviews.

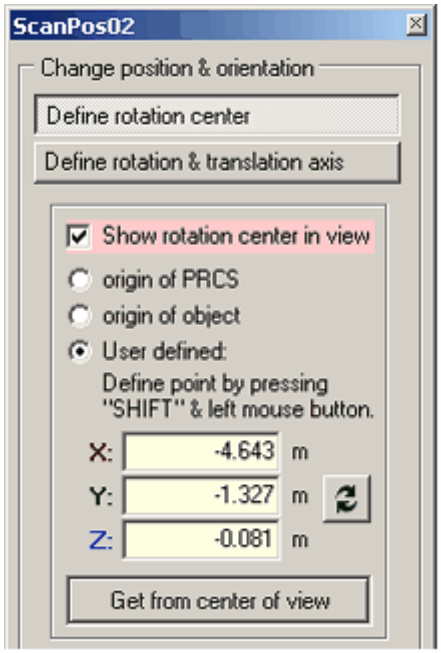
1. Open or create an object view

2. Insert the scan position(s) you want to modify into the object view (drag the scan position from the projectmanager and drop it onto the view window). To get a visual feedback of the modifications you should also insert some data according to this scan position.

3. Insert some reference data (which will not be modified, e.g. already registered scan positions) into the object view

4. To change the position and/or orientation right-click on a scan position in the object inspector and select "Modify SOP…" (to modify other objects select "Modify...")

5. Define rotation center (only necessary if you want to rotate the scan position, jump over to step 6 otherwise).



To rotate the scan position it's necessary to define a rotation center. To define the center you can use different methods:

- **Origin of PRCS*:***
  The origin of the project coordinate system is used.

- **Origin of object*:***
  The origin of the object is used.

- **User defined*:***
  You may define any point that meets your requirements. To do so select one of the following methods:

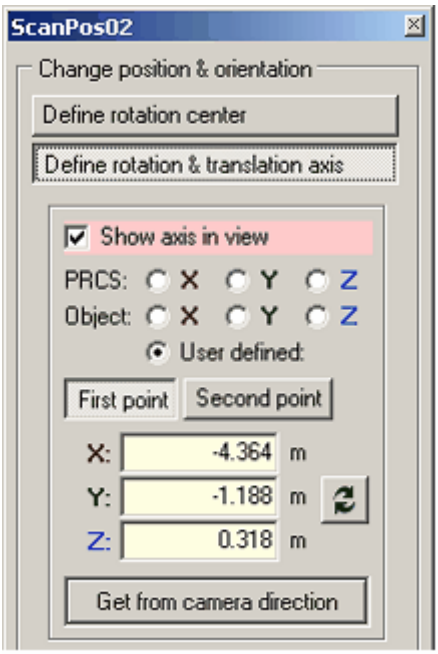
  1. Press and hold the "SHIFT" key and click with the left mouse button on a point in the object view (see also step 7: Mode). You can activate this mode from the object view by pressing "1", when you are in the modification mode.

  2. Enter the coordinates of the point directly. Press the button beside the coordinates in order to update the display of the rotation center.

  3. Click on the button "Get from center of view". This will take the 3D point next to a virtual ray going through the center of the view window.

To display the a small sphere at the center of rotation select the option "Show rotation center in view".

6. Define rotation and translation axis:



At this step you can define the axis to be used for rotation or translation. To define the axis you can use different methods:

- **X, Y, Z axis of PRCS**
  The X, Y or Z axis of the project coordinate system will be used.

- **X, Y, Z axis of object**
  The X, Y or Z axis of the object will be used (see also option "Show axes of object" described below).

- **User defined:**
  You may define any desired axis. To do so select one of the following methods:

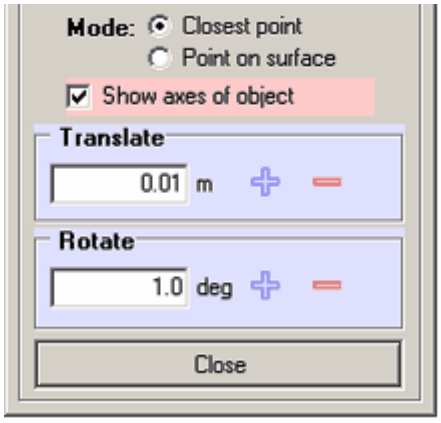
  1. Define axis by selecting two points from the view. To select the first point click on the button "First point". Then press and hold the "SHIFT" key and click with the mouse button on a point in the object view (see also step 7: Mode). Click on the button "Second point" and repeat the point selection. You select "First point" and "Second point" from the object view you can also press keys "2" (first point) and "3" (second point).

  2. Define axis via input of coordinates of two points. To enter the coordinates of the first point click on the button "First point". Then enter the coordinates of the first point. Click on the button "Second point" and repeat the procedure. Use the button beside the coordinates in order to update the display of the axis.

  3. "Get from camera direction". When you click on this button the axis normal to the screen surface is used.

To display the axis as a line in the 3D-scene select the option "Show axis in view".

7. Finally rotate/translate the scan position



Mode:
With that mode you can determine which point should be used when you define the rotation center or the rotation/translation axis:

- *Closest point*
  The 3D point next to the mouse cursor will be taken:

- *Point on surface*
  The intersection point between the surface (triangle or plane) and the ray defined by the mouse cursor will be taken.

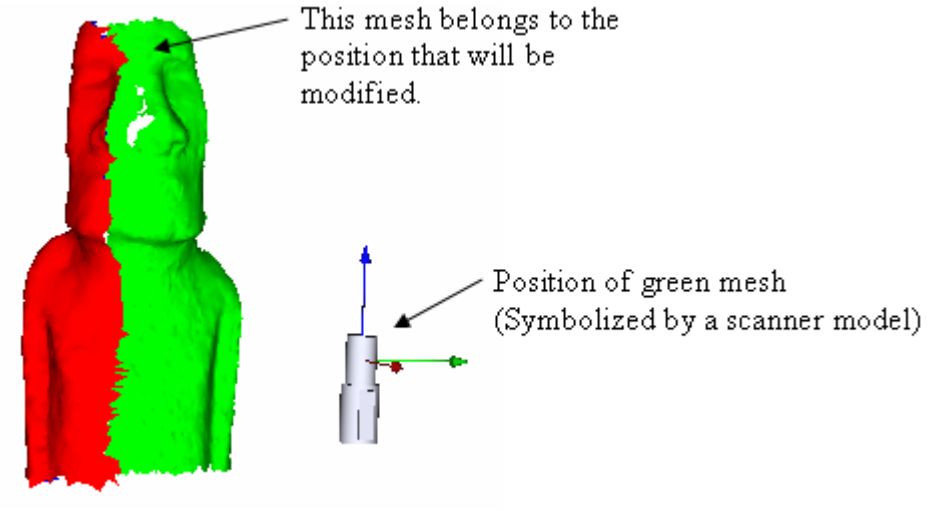
With the option "**Show axes of object**" you can decide whether to display the axes of the object or not. This is especially helpful to define the rotation axis as described above.

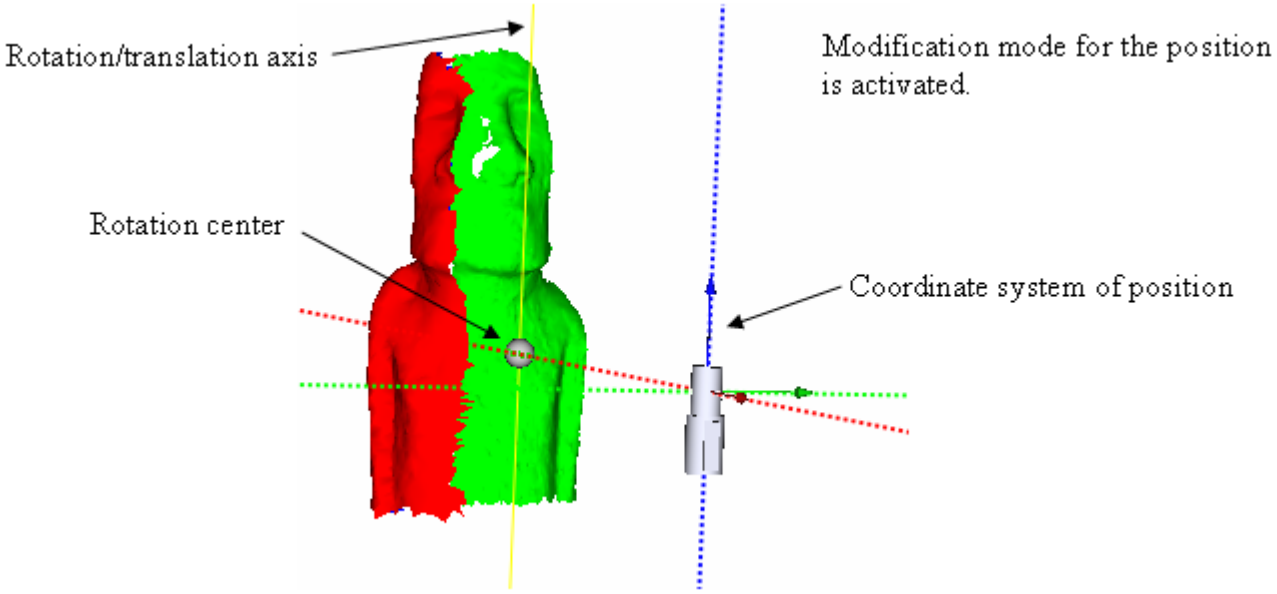
Translate:
Define the move increment.
Use the "+" button to move the scan position along the positive axis.
Use the "-" button to move then scan position along the negative axis.

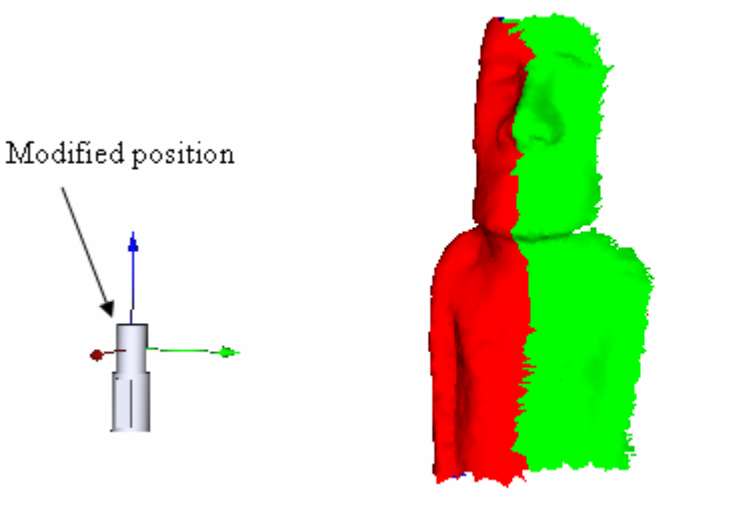
Rotate:
Define the rotation increment.
Use the "+" button to rotate the scan position clockwise around the axis.
Use the "-" button to rotate the scan position counterclockwise around the axis.

Clicking once on the "+" or "-" buttons will move or rotate the scan position one step according to the defined increment. Holding down the button for some time will repeatedly move or rotate the scan position until you release the button.

Example: *Aligning two meshes by modifying the corresponding position*


This mesh belongs to the position that will be modified.
Position of green mesh (Symbolized by a scanner model)


Rotation/translation axis
Modification mode for the position is activated.
Rotation center
Coordinate system of position



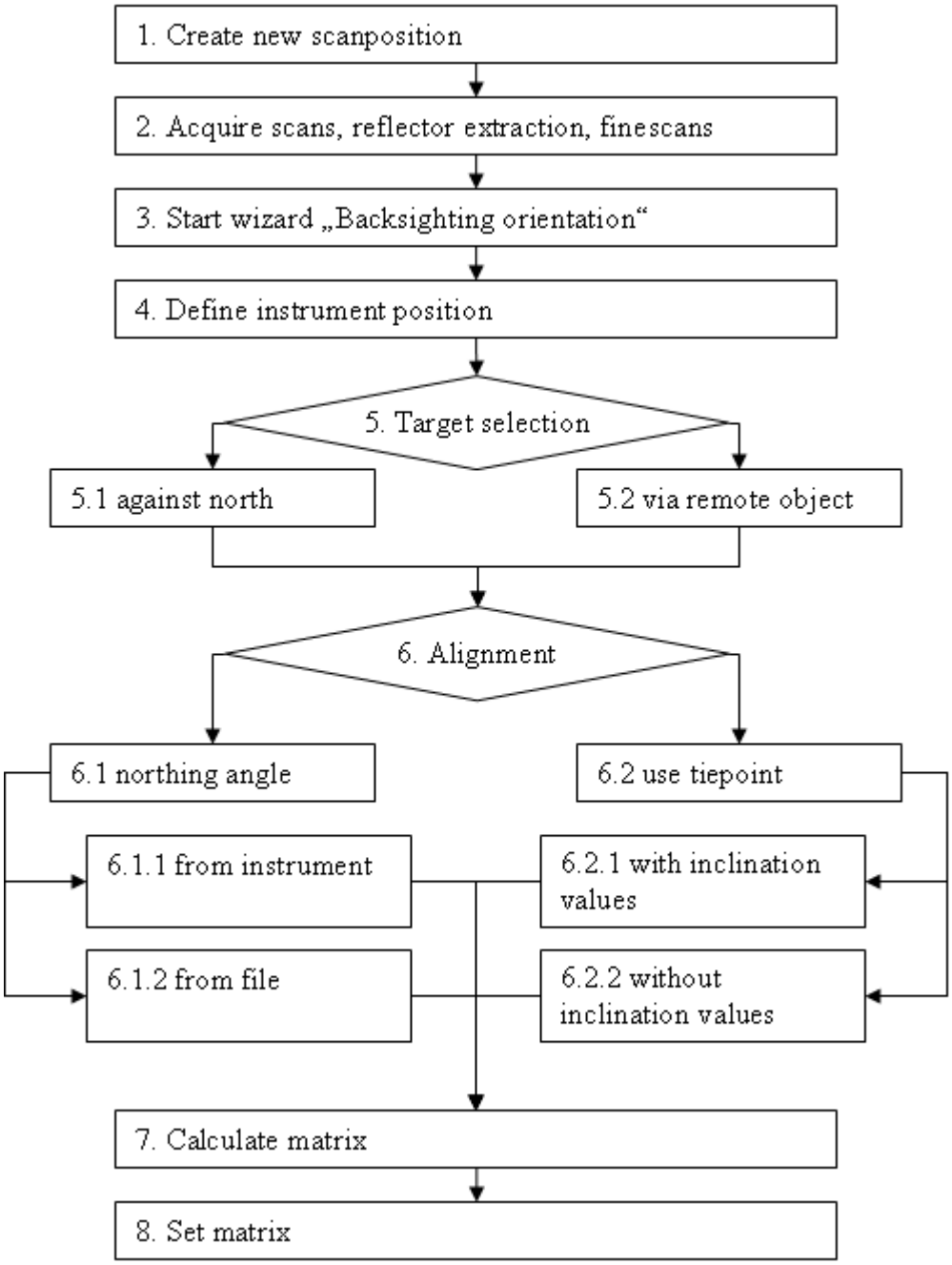
The two meshes are aligned after the modification operation. You can see that the position has new coordinates.

6.4 Backsighting

Calculate orientation and position via backsighting

You can use this tool to register (approximate) the scan position using the well known coordinates of a certain point and the coordinates of a remote object (e.g. a church).

Flow chart of general workflow:



1. Create a new scan position

Setup the scanner accurately vertically (head up, Z axis anti parallel to the gravity vector).

Note:
If the instrument has built-in inclination sensors and you decide to use option 6.2.1 you don't need to align the scanner accurately.

Create a new scan position by right-clicking on the folder "SCANS" and selecting "New scan position".

2. Acquire scans, reflector extraction, finescans

Acquire the desired scans. If you would like to use a reflector as remote target (step 7.2) then you also have to do the reflector extraction and finescan the desired reflector.

3. Start wizard "Backsighting orientation"

Open the wizard "Backsighting orientation" by right-clicking on the SOP of the scan position and selecting "Backsighting orientation...".

4. Define instrument position

On the first page enter the scanner's own position in global coordinates. If you use a GPS mounted on the scanner you can import the coordinates by using a *.uda file (Format: "Name, X, Y, Z") by clicking on the button "Read from file". Open the *.uda file and select one entry (=position) from the list.

"Instrument height": Insert the vertical offset between the well known ground point and the laser beam exit, indicated at the scanner head.

5. Target selection

On the second page you can decide how to align the scanner: either "via remote object" or "against north".

5.1 Against north

If "via remote object" is selected, enter the coordinates of a remote object in global coordinates (There is also the GPS import via *.uda file available - see step 4).

5.2 Via remote object

If "against north" is selected you should align the scanner against north (see next paragraph).

6. Alignment

Now you have to define the rotation around the Z-Axis of the scanner (the orientation of the instrument called "Northing angle").

6.1 Northing angle

In that case you have to turn the scanner until the remote target is within the telescope or the compass points to north respectively. To use the northing angle
click on "Use northing angle".

"PARALLAX": Insert the horizontal offset between the center of the telescope and the center of the scanner.

6.1.1 From instrument

The retrieve the northing angle from the instrument please check the checkbox "Connect to device". You can now use the wizard to turn the instrument.
A single click on "Turn left" or "Turn right" will cause the scanner start moving. To stop it again click on the button "Stop turning". As an alternative you can press the keys "A" and "D" on the keyboard to turn left and right. The scanner will move as long as you press the key.

To regulate the frame speed use the slider (left means less speed, right means higher speed).

After the scanner has been aligned click on the button "Get angle from device" to read the phi angle from the scanner (the "Northing angle" field is not updated after every movement!).

6.1.2 From file

The northing angle can also be loaded from file. Thereto you need a standard text file containing the northing angle. Such a file can be created manually or it can is created with the wizard by a click on the button "Save to file".

6.2 Use tiepoint

In that case you need a finescanned reflector (step 2). The northing angle is automatically calculated from the reflector position gained by the scanner.
To use a tiepoint click on "use tiepoint" and click on the button "Select tiepoint". Select the desired tiepoint from the list.

6.2.1 With inclination values

If the instrument has build-in inclination sensors you could use these measurements to automatically align the scanner vertically. To inclination values are saved to each scan. If you check the checkbox "Use inclination sensor values" the inclination values of the finescan of the selected tiepoint will be used.

6.2.2 Without inclination values

In that case you have to ensure, that the scanner is vertically aligned (see also step 1). Uncheck the checkbox "Use inclination sensor values".

7. Calculate matrix

On the fourth page you can see a summary of the given data and the calculated matrix. At this step you can still go back to one of the previous pages in order to correct wrong settings.

8. Set matrix

To really write the matrix to the SOP of the scan position click on the button "Set SOP". Before the matrix is written to the SOP, RiSCAN PRO checks if a modification of the POP-matrix is necessary. If so you will be prompted to confirm these values and the SOP is modified according to the new POP.

Finally click on the button "Close" to close the wizard.

6.5 Registration of project images

Images saved at project level are images which may have been acquired for instance while the camera was not mounted on the scanner such as detail images. Thus these images are not registered within the project coordinate system. RiSCAN PRO offers a function to register these images via defining relations between image points and project points. It's recommended that you do the registration of project images not before you have registered all scan positions and the project.

The following step by step description shows how to register a project image:

- **Define tiepoints in PRCS**

  During the registration of the scan positions the TPL PRCS should have been filled with coordinates (tiepoints and/or controlpoints). To register a project image it is necessary that at least 3 points of the TPL PRCS are visible in that image. If not you may create helping points by defining a tiepoint in a scan (TPL SOCS) and copying it to the TPL PRCS.

- **Define image tiepoints**

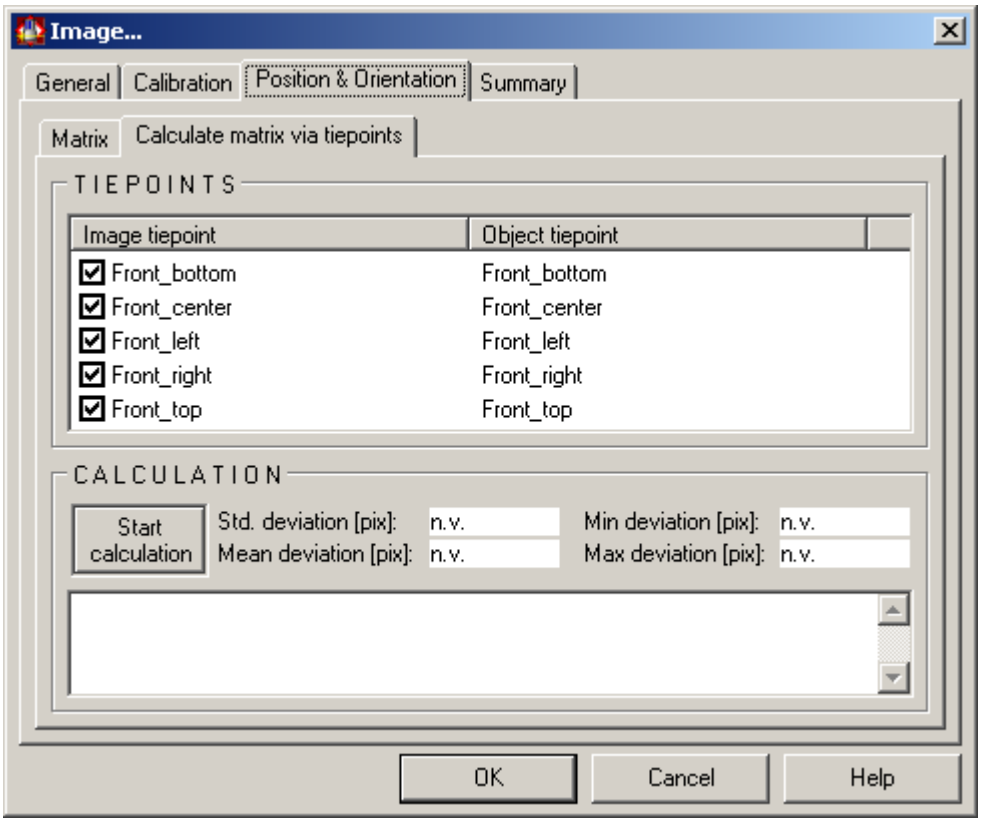
Now you have to add image tiepoints for each PRCS tiepoint which can be seen in the current image (see 2D view: General 97).
Hint: To make the next step easier, it's recommended to name the image tiepoints like the corresponding PRCS tiepoints.

- **Link image tiepoints to PRCS tiepoints**

  Open the TPL PRCS and the TPL of the image. Establish the links between the corresponding tiepoints via drag and drop (e.g. drag the image tiepoint and drop it onto the corresponding PRCS tiepoint).

- **Registration of image**

  Click with the right mouse button on the image within the project manager and select "Attributes..." from the menu. In the attributes dialog of the image switch over to the page "Position and orientation". Within this page switch over to the page "Calculate matrix via tiepoints":



In the box "TIEPOINTS" you can see a summary of the tiepoints which will be used for the calculation. The left column shows the names of the image tiepoints and right column shows the name of the linked tiepoints. To activate or deactivate tiepoints click on the small box in front of the name of the image tiepoint (hook displayed = activated, hook not displayed = deactivated).

To finally start the calculation click on the button "Start calculation". In the box on the bottom of this page you can see a log of the calculation. When the calculation is finished, the quality of the registration is written to the boxes ("...deviation") and the resulting COP matrix (transforming from image coordinate system to project coordinate system) is written to the first page "Matrix". To save the result click on the button "OK".

Hint: If the result seems to be bad please check the linkage of the tiepoints and deactivate some tiepoints if necessary.

6.6 Hybrid multi station adjustment

The Hybrid Multi Station Adjustment (HMSA) is a RiSCAN PRO plugin which tries to improve the registration of the scan positions. For that purpose the orientations and positions of each scan position are modified in several iterations in order to calculate the best overall fit of them.

Note: The menus described below are available only when the plugin is installed.

Where to get the plugin:

You will find the plugin on the RiSCAN PRO download page 202

How to use the HMSA:

1. First of all do the registration as usual (see "Data registration 125").

2. Select the scan positions to be modified:
   By default each registered scan position will be included into the calculation. To change this, open the TPL SOCS of the scan position you want to disable and deactivate it. (see "The tiepointlist window 78").

3. Start the HMSA: click on the menu "Tool" > "Hybrid Multi Station Adjustment" and then select "Start calculation".
   The HMSA begins the calculation. You can watch the progress in the Messagelist or the Threadlist. When the HMSA is finished the SOPs of all activated scan positions will be modified according to the calculation results. Also the position of the tiepoints in the TPL PRCS (not controlpoints!) will be modified.

4. To check the results you can compare the deviations displayed on to top of the TPL SOCS of each scan position.

5. If you are not satisfied with the result you can undo the calculation by clicking on "Tool" > "Hybrid Multi Station Adjustment" and selecting "Undo last calculation". This will restore the original SOPs (As an alternative you can also restore just single scan positions by right-clicking on the corresponding SOP and selecting "Undo" from the menu).

Part VII

Data postprocessing

7 Data postprocessing

7.1 Data manipulation

7.1.1 Select

In an object view you can select data in order to do some operations with the selected parts. If you want to select data, you have to activate the selection mode and set the selection properties. You can find a description of the available properties in the table below. After selecting some data you can see the selected areas colored with the selection color, which you can define in the program options 24. In the status bar of the object view you can also see how many points and triangles are selected. How to work with selected data see "Actions on selected data 144".

Button	Action	Comment
	Selection mode	Activate/deactivate selection mode. You can also activate this by pressing the "SPACE" key in the object view.
	Rectangular selection	Keep the left mouse-button pressed while moving the mouse to create the desired rectangle.
	Polyline selection	Press the left mouse-button to define the edges of the polyline. The right mouse-button will finish the selection.
	Freeform selection	Keep the left mouse-button pressed while moving the mouse to create the desired selection.
	Triangle selection	Press the left mouse-button to select the corresponding triangle (polydata).
	Mark selected area	When this is activated, the selected area will be marked.
	Toogle selected area	All marked data of the selected area will be unmarked and all unmarked data of the selection will be marked.
	Unmark selected area	When this is activated, the selected area will be unmarked.
	Inside filter	When this is activated and a selection is applied, all the data inside the selection are selected.
	Outside filter	When this is activated and a selection is applied, all the data outside the selection are selected.
	Front face	Select only triangles, which have a normal vector pointing to the camera.
	Back face	Select only triangles, which have a normal vector pointing away from the camera.
	Select only whole triangles	This will select only those triangles, that are completely selected.
	Select all triangles	Select all triangles that are partially selected.
	Toogle selection	Toogles the selected area. All marked data will be unmarked and all unmarked data will be marked.
	Deselect data	All marked data will be unmarked.

7.1.2 Actions on selected data

When you have selected some data you can perform several actions. How to select data see "Select data 143". In the table below you can see a description of available operations with the selected data.

Button	Action	Comment
	Show LSQ plane info	Provides information about the selected data.
	Remove selected traingles	Removes all selected triangles, but the point information will remain.
	Delete selected area	All selected data will be deleted.
	Delete selected area and create new polydata object	Creates a new polydata object from the selected data and delete then all the selected data .
	Create new polydata object	Creates a new polydata object from the selected data.
	Hide selected area	All selected data will be hidden.
	Show only selected area	Only selected data will be visible.
	Show all	All hidden data will be visible.
	Triangulate	Starts triangulation mode.
	Smooth & Decimate	Starts smooth & decimate action.

Triangulation ... for more information see triangulation of arbitrary point clouds 153.
Smooth & Decimate ... for more information see smooth & decimate 155.

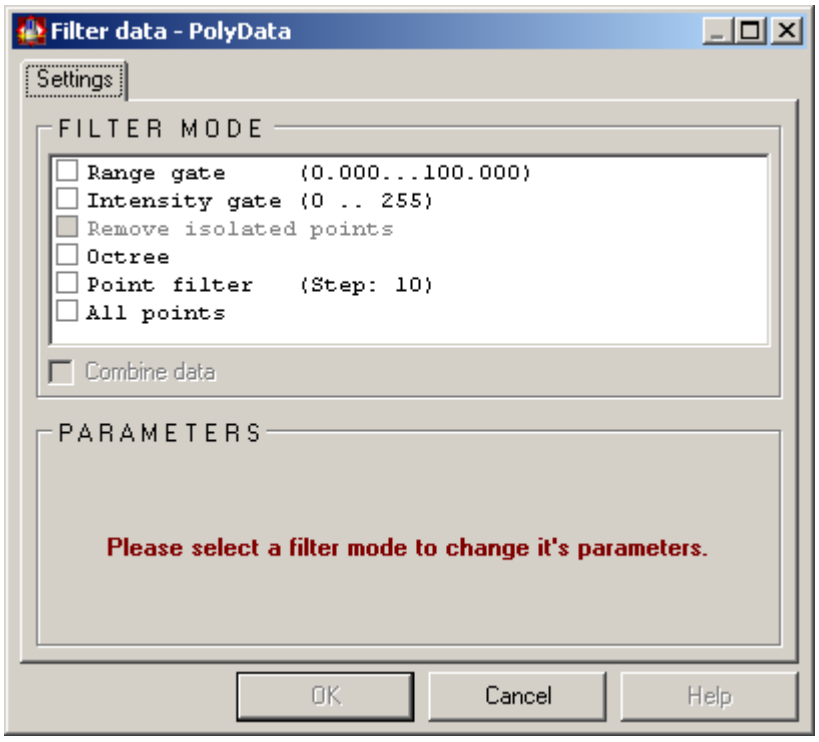
You can also define a plane from the selected data, see "Create plane 173".

7.1.3 Filter

You can manipulate data objects (Scans and Polydata) by defining some filter operations. You can filter a single object, but you can also do this with multiple objects.

- **Single object:**
  Activate the popup menu of a scan or a polydata and select "Filter data…"
- **Multiple objects:**
  To filter multiple objects just activate the popup menu of a "POLYDATA" folder (you can locate such a folder in the project manager within a scan position or in the "OBJECTS" folder) and select "Create new polydata…"

The following dialog appears:



In this dialog you can define some parameters for different filters. When filtering multiple objects you can also select which data objects you want to use (on the page called "Data" which is not visible on this screenshot) and whether you want to combine all selected data to one single data object ("Combine data").

Following filters are available:

- **Range gate:**
  Only data within a specified range is added to the resulting polydata object. The range is always calculated in the coordinate system of the object.

- **Intensity gate:**
  Only data within a specified intensity range is added to the resulting polydata object.

- **Remove isolated points:**
  A point is added to the resulting polydata object, when at least a minimum number of surrounding points has a distance smaller than a given value. This filter is only available for a scan (3DD file).

- **Octree:**
  This filter procedure is done by using an octree structure. That structure is based on a cube which is divided into 8 equally sized cubes which are again divided and so on. The extension of the base cube can be entered in the dialog (min and max X, Y, Z). The division into sub cubes is done on demand by filling the points into the octree and stopped as soon as a given minimum cube size is reached (Increment X, Y and Z, usually between 0.1 and 1.0 m).
  After generation of the octree, one cube contains one point, which is the center of gravity of the averaged points representing in general a larger number of points.

  Note: The resulting object contains only point information no matter what type of source data you have selected.

- **Point filter:**
  Only each n-th point is added to the resulting polydata object (n is the user defined factor).

- **All points:**
  All points will be added to the resulting polydata object (you can use this filter to clone objects, or to combine objects).

The result of a filter operation is always a polydata object.

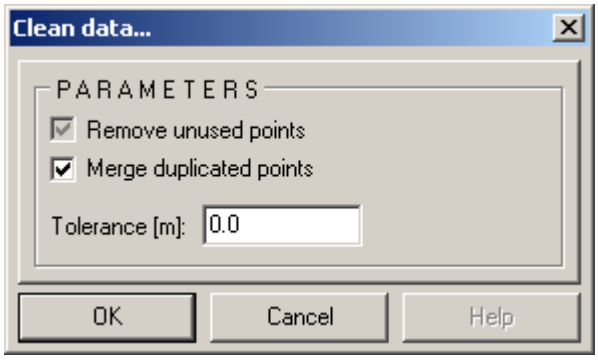
Note:
When you've started the filter action from the folder "OBJECTS/POLYDATA" the place the resulting polydata object is saved depends on the setting of the "Combine data" option:

Combine data activated:
All data will be saved within one single polydata object located in the folder "OBJECTS/POLYDATA".

Combine data deactivated:
For each selected source polydata object a new polydata object in the same folder will be created containing the filtered data.

7.1.4 Clean

You can clean up the data of a polydata object, by selecting it in the project manager and activate the popup menu. Then select "Clean data…" and following dialog appears:



- **Remove unused points:**
  All points which are not referenced by any data array (such as point cloud or triangulation) will be removed (this option is always activated, because you can not take use of unreferenced points).

- **Merge duplicated points:**
  Points with the same point coordinate will be merged to a single data point.

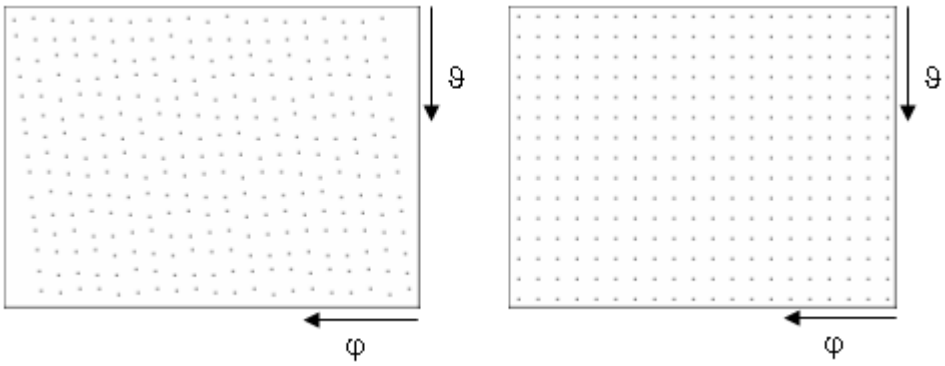
- **Tolerance:** (only available for point clouds)
  If this value is greater than zero, then points within a specified tolerance will be merged to a single data point. This value is only used when "Merge duplicated points" is activated.

To finally start the cleanup procedure click on the button "OK". The resulting data will be saved in a polydata object located in the same folder as the source polydata object.

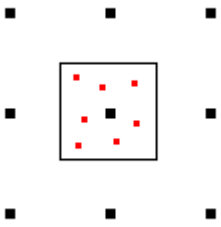
7.1.5 Resample

General aspects

Scan data of RIEGL laser scanners can be addressed in most cases as an organized point. The scan data are acquired sequentially on a more-or-less regular grid in a ϑ–φ plane, where ϑ and φ denote the polar 203 angle and the azimuth 203 angle, respectively. This data acquisition can also be addressed as taking the scan line-by-line in azimuth direction and measurement-by-measurement within one line in polar direction (compare the left diagram in the Figure below).



By re-sampling a scan a new grid in the ϑ–φ plane is generated. The extents of the grid is defined by one of the original scans to be re-sampled. The resolution of the grid is defined by the user in a dialog. During the process of re-sampling all range and intensity data falling within one cell of the grid are averaged (red dots in the figure below). There are different options and parameters influencing the averaging which are discussed below in more detail. The result of re-sampling is a 3D data set with a strictly regular grid in the ϑ–φ plane (compare the right diagram in the Figure above).



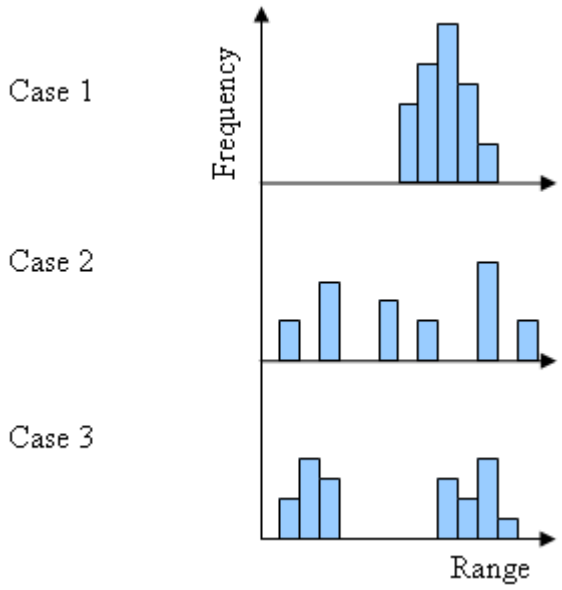
In the following cases re-sampling scan data is of advantage:

- Reducing range and intensity noise by re-sampling of a scan sequence or of a number of scans taken at the same scan position.
- Reducing range and intensity noise by re-sampling a single scan with a lower scan resolution.
- Removing temporal targets from a scan sequence, e.g., cars moving on a highway.

Controlling the averaging process

During the re-sampling process each grid cell will contain a number of data (measurements) before executing the averaging of range and intensity data. The figure below shows three different examples for the distribution of range within a single cell of the grid. Wether the final cell will have a valid range or not is judged on the basis of the standard deviation which is compared to a threshold. In case 1 all the range data are distributed near an average range and the standard deviation is quite low. In case 2 the range data are distributed fairly wide giving a quite large standard deviation. The data may arise from measurements taken at, e.g., walking pedestrians. In case 3 we have two distinct ranges with low variation each.

The averaging process is controlled by the option "remove near range clutter signals" and the threshold defined within the Options|Averaging/Resample.



"last target only" OFF

In this case the standard deviation of all range data with every cell is calculated and compared against the threshold value. In case the deviation is smaller than the threshold, the range in the cell is set valid and is set to the average range. In the examples described above, only in case 1 a valid range would be calculated.

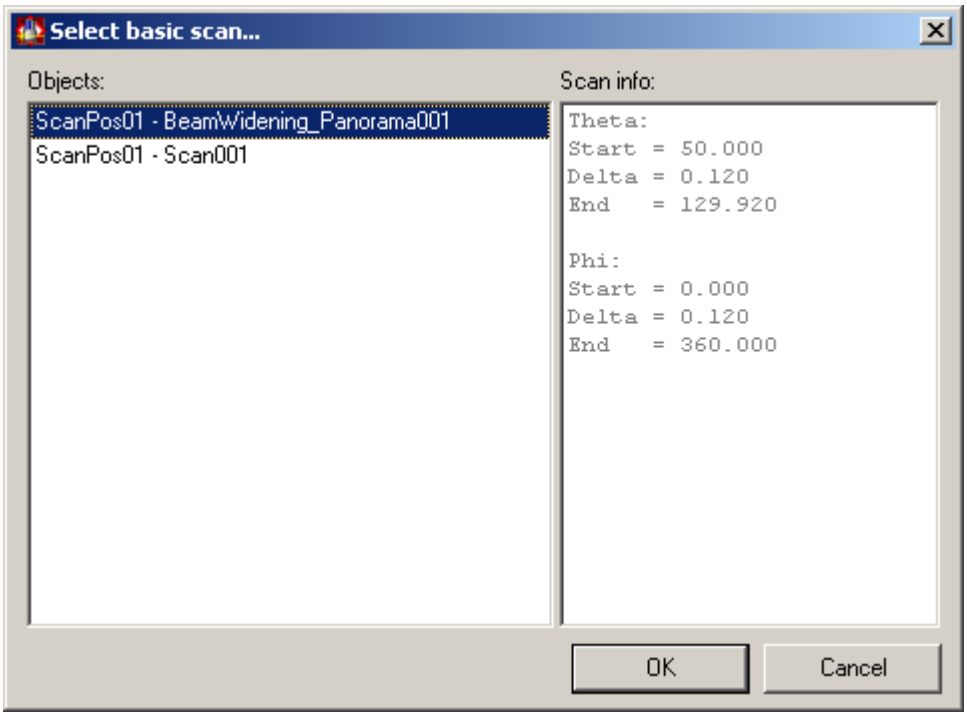
"last target only" ON

This mode allows to suppress near range clutter signals. In this case **only** the range values larger than the maximum range minus five times the threshold value are considered for standard deviation calculation and averaging. In the examples described above cases 1 and 3 will give valid ranges.

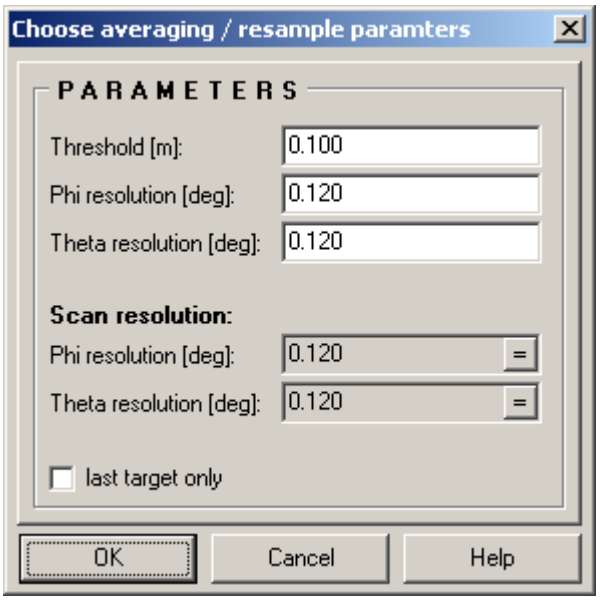
Resample example:

If you want to resample one (or more) scan(s), then mark the scan(s) and click the right mouse button. Choose "Resample..." from the context menu.

If you decide to resample more than one scan, you have to define the basic scan. That means that this scan is used to adjust the resample parameters and the dimension (angular extents).



The next step will be to set up the resample parameters. (Description see above 148)



You can use the "=" - buttons to set the output resolution equal to the scan resolution.

7.2 Triangulation

Triangulation is the process to create a surface out of a point cloud where the surface is made up by triangles connecting the data points. Triangulated data (also called "mesh") gives a better representation of the scanned object. Additionally triangulated data can be textured 161 with the high resolution images taken by the digital camera which leads to a nearly photo realistic model.

In RiSCAN PRO two different functions to triangulate data are implemented:

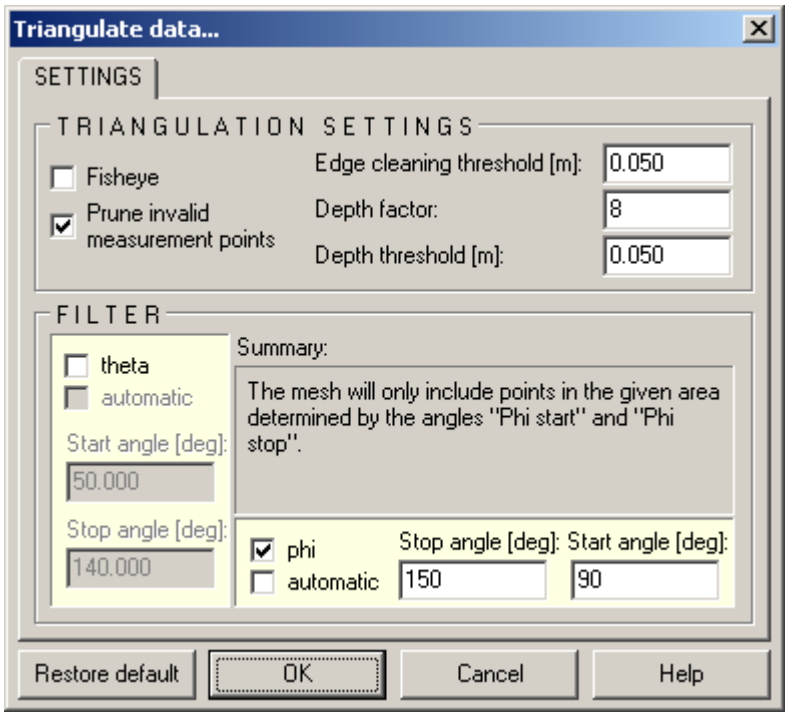
- Triangulation of a scan 151
  This function can be used to triangulate a point cloud (a 3DD file) automatically. This function is only applicable on point clouds acquired with a scanner and thus located at a scan position.

- Triangulation of arbitrary point clouds 153
  This function is more interactive. The user defines which part of the point cloud should be triangulated. Therefore it is an iterative process where small parts of the point cloud are triangulated until the desired result is reached. This function can be used for any arbitrary point cloud located either at a scan position or in the folder "OBJECTS" (project coordinate system).

7.2.1 Triangulation of a scan

Triangulation is a process to create a surface from a point cloud by connecting the points with triangles.

Right-click on a scan and select "Triangulate scan...".



TRIANGULATION SETTINGS

- *Fisheye*

  This function is used for debug purpose.

- *Prune invalid measurement points*

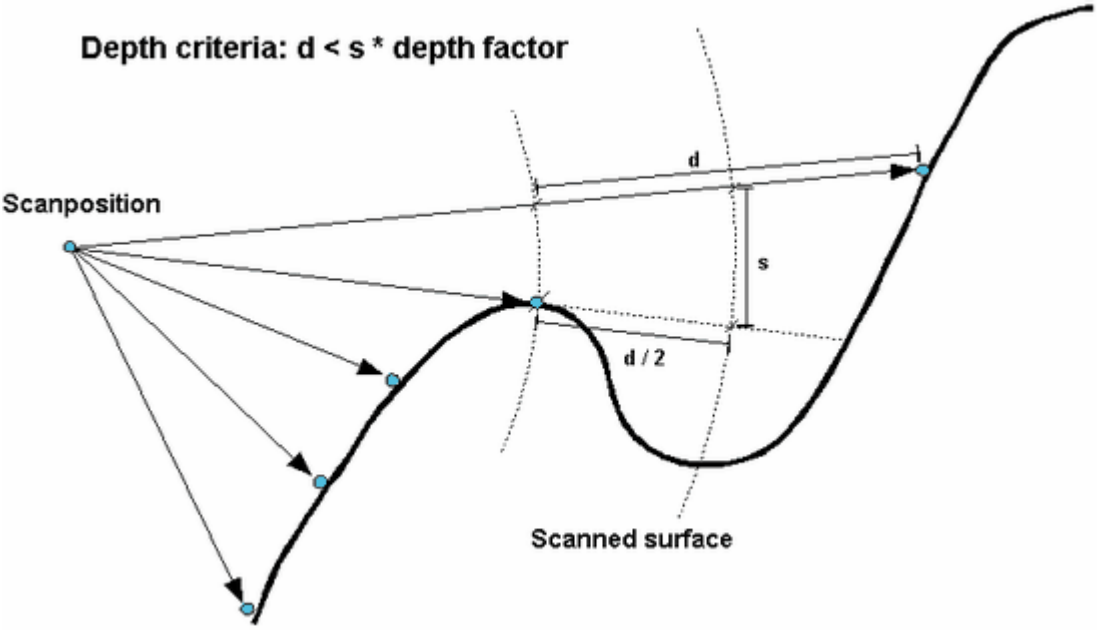
  Points that have angles but do not contain measurement information will be neglected.

- *Edge cleaning threshold*

describes the quality of the edges.
Note: if this value is set to a small value (high quality), the surface might contain holes.

- *Depth factor*

  defines the valid edges of a triangle. Each two edges of the triangle have to satisfy the following criteria:



- *Depth threshold*

  Points that are very close to each other may produce an unpredictable orientation of triangles. Setting this value higher than the noise level would preserve these triangles.

FILTER

Limit the output by selecting a range from the mesh.

- *theta*

  refers to the vertical output of the mesh. Possible values range from 0° - 180°.

- *phi*

  refers to the horizontal output of the mesh. Possible values range from 0° - 360°.

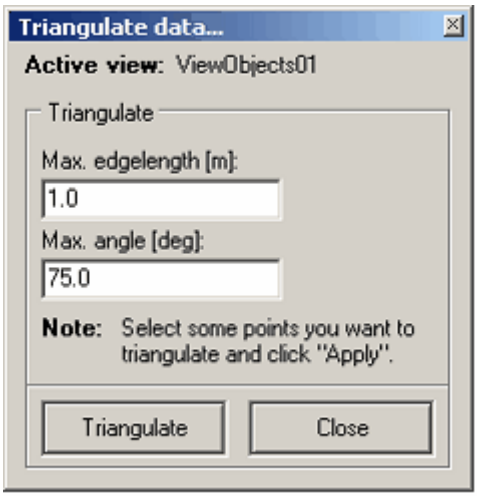
The triangulation process will create an image in the folder "POLYDATA" having the identical name as the scan. You can view the generated image by double-clicking it or by right-clicking the image and selecting "View...".

If you are visualizing an image in 2D, you can triangulate a part of the image by holding down the Alt-key while pressing the left button of your mouse and moving the cursor to create a rectangle.
Click on the button "Preferences" from the menu and select "Triangulate scan...".

7.2.2 Triangulation of arbitrary point clouds

A 2D-Delaunay triangulation algorithm is used to triangulate the data. The Delaunay triangulation is computed from the 2D coordinates of the points mapped onto the computer screen.

1. Right-click in an object view window and select "Triangulate...". The following dialog will appear:



TRIANGULATION SETTINGS

- *Max. edge length*

  Defines the maximal length of the edges for a triangle. That means if one edge of a triangle is larger than the specified value the triangle is removed.

- *Max. angle*

  Defines the maximal angle between the triangle normal and the ray of sight. If the angle is larger than the specified value the triangle is removed.

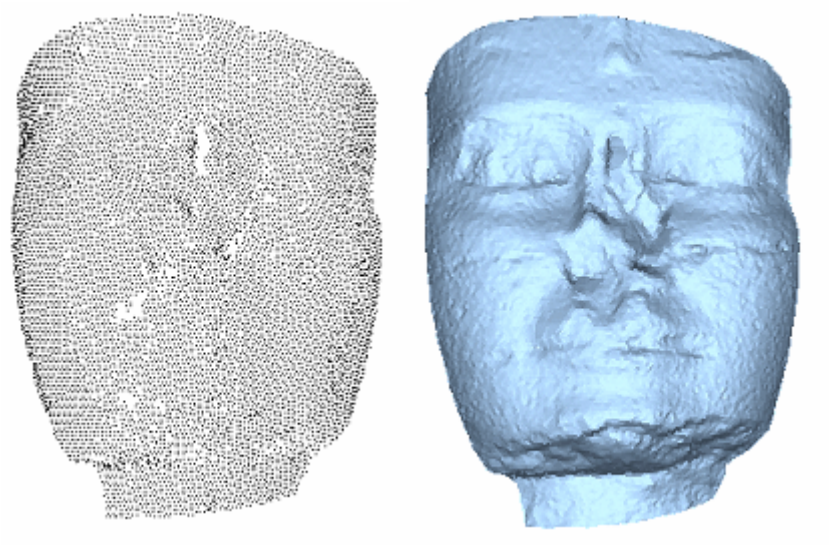
2. Select some points of the point cloud you want to triangulate.

3. As mentioned above the triangulation is done from the current point of view. Thus rotate the point cloud in order to get a good viewpoint. Overlapping points should be avoided.

4. Then adjust the settings and click "Triangulate".

   The resulting triangles will be marked as highlighted, so if you are not satisfied with the result you can easily undo the last operation by pressing the button "Remove selected triangles". 

   Example:



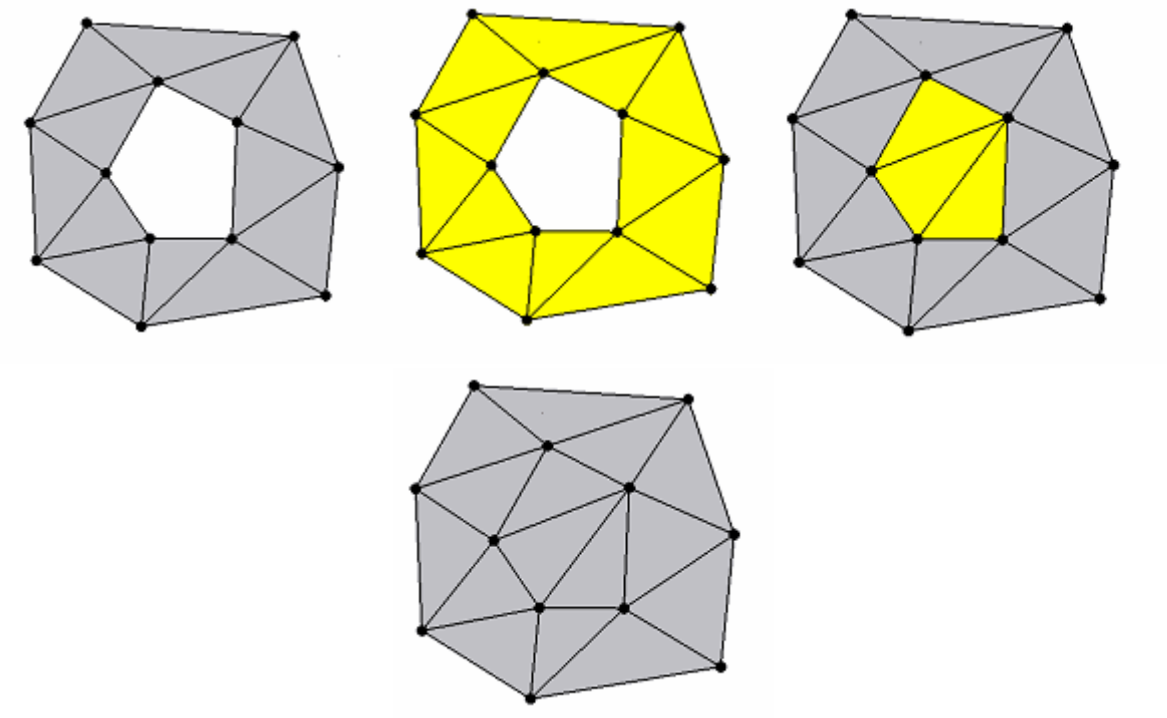
10500 points 21000 triangles

Hint: If the point cloud represents a very complex surface it's better to select at one step just a small area and to repeat the triangulation procedure with a new point selection until the surface meets your requirements.

You may also use the triangulation for hole filling:

First of all select the surrounding triangles of the hole. Then perform the triangulation described above.

. Initial Mesh Select surrounding triangles perform triangulation after triangulation .



7.2.3 Triangulation of a plane

RiSCAN PRO offers the possibility to triangulate a plane object 173. To do so click select on ore more planes in the project manager. Right click on the selected plane(s) and select "Create polydata..." from the menu. A dialog to configure this process appears:

Resolution - enter the maximum triangle size here

Combine data - activate this option in order to create just one polydata object containing all planes. If this function is deactivated a polydata object for each select plane object is created.

Click on the button "OK" in order to create the polydata object(s).

7.3 Working with meshes

7.3.1 Smooth & decimate

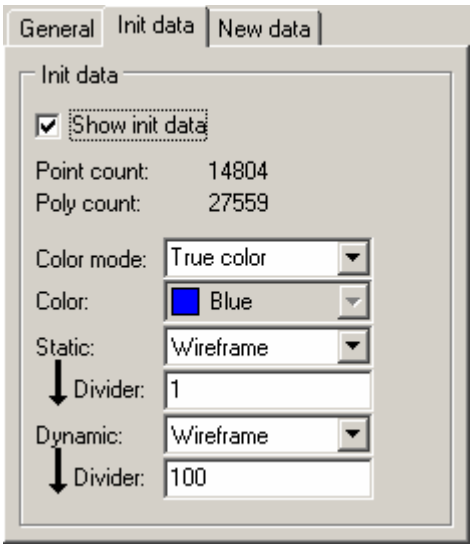
This function modifies the surface structure of the polydata object by optimizing the point data (smoothing) and reducing the amount of triangles (decimating).

This menu can be called by right-clicking on an object from the directory "POLYDATA" (the object has to be triangulated - see Triangulation of a scan 151 and Triangulation of arbitrary point clouds 153 - but must not be textured) within the project manager window or by right clicking anywhere within the Object view 102 window.

Sheet "General"

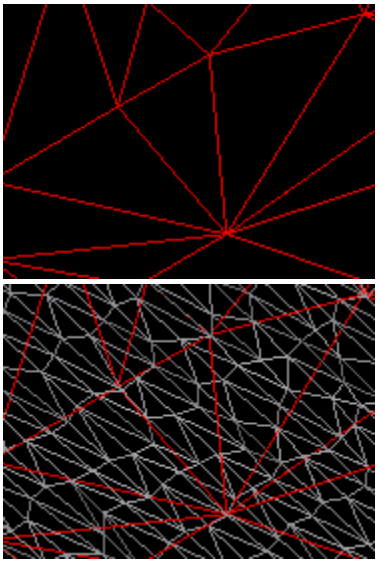
this tab provides some settings on the view and the background color

Sheet "Init Data"



- ***Show init data***

if this option is activated and changes have been applied, the Initial data will be visible together with the New object in the bottom screen.
Note: to better visualize a difference, choose a different color for the Init data (disable the option "Apply change to all")!


New data with "Show init data"
New data without "Show init data"

- ***Color mode***

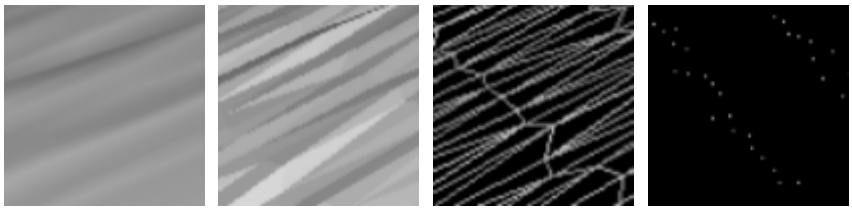
choose between single and true color

- ***Color***

if the color mode is set to single color, select the desired color from the list.

- ***Static***

select the type of structure that should be applied to the object:



Polygon smooth Polygon flat Wireframe Points

- ***Divider***

reduces the amount of points that are shown. The number of points is divided by the value entered here.

- ***Dynamic***

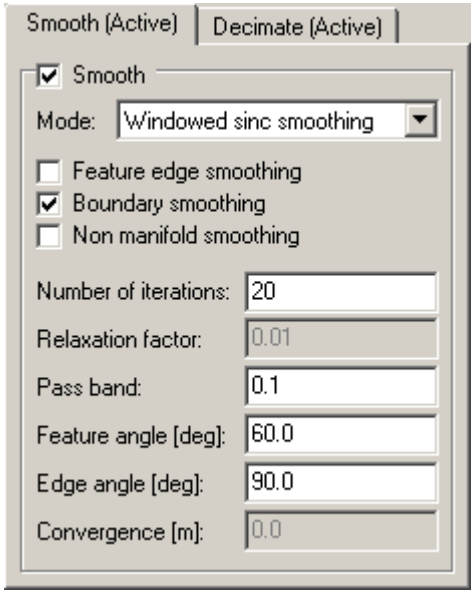
same as Static, with the exception that these settings will be applied during any movement of the object

Sheet "New Data"

Provides the same information as the initial data for the new object

Sheet "Smooth"

is a process to optimize the coordinates of the point data to make the surface smooth while preserving the amount of polygons and points.



- ***Smooth***

  if this option is enabled, the settings will be applied to the New data.

- ***Mode***

a filter to make cells better shaped and vertices more evenly distributed

Laplacian smoothing - the coordinates are modified according to an average of connected vertices to reduce high frequency information in the geometry of the mesh.

Windowed sinc smoothing - the coordinates of each vertex are modified using a windowed sinc function interpolation kernel (Taubin describes this method in the IBM tech report RC-20404 (#90237, dated 3/12/96) "Optimal Surface Smoothing as Filter Design" G. Taubin, T. Zhang and G. Golub).

- ***Feature edge smoothing***

  Excessive smoothing may lead to a loss of important details and the surface may shrink towards the centroid. Enabling this feature will help reduce this effect.

- ***Boundary Smoothing***

  enables the smoothing operation of vertices that are on the boundary of the mesh.

- ***Non manifold smoothing (*only available with Windowed sinc smoothing)**

  smooth non-manifold vertices.

- ***Number of iterations***

  determines the number of times the smoothing algorithm will be applied.

  Note:
  when using the Windowed sinc smoothing, the value should be between 15-20; when using the Laplacian smoothing, the value should be between 10-200.

- ***Relaxation factor (*only available with Laplacian smoothing)**

  defines the amount of displacement for the modification of the vertex coordinates.

  Note:
  as in all iterative methods, the stability of the process is sensitive to this parameter. In general, small relaxation factors and large numbers of iterations are more stable than larger relaxation factors and a small number of iterations.

  Default value = 0.01

- ***Pass band (*only available with Windowed sinc smoothing)**

  limits the frequency modes in a polyhedral mesh.
  Valid values: 0.0 - 2.0 (default = 0.1)

  Note: a lower value will produce more smoothing.

- ***Feature angle***

  This angle is used to define edges between two triangles (i.e. if the surface normal between two adjacent triangles is greater or equal to the feature angle, an edge exists).

- ***Edge angle***

  Vertices are smoothed along their connected edges, if the angle between their edges is less than the value entered here.

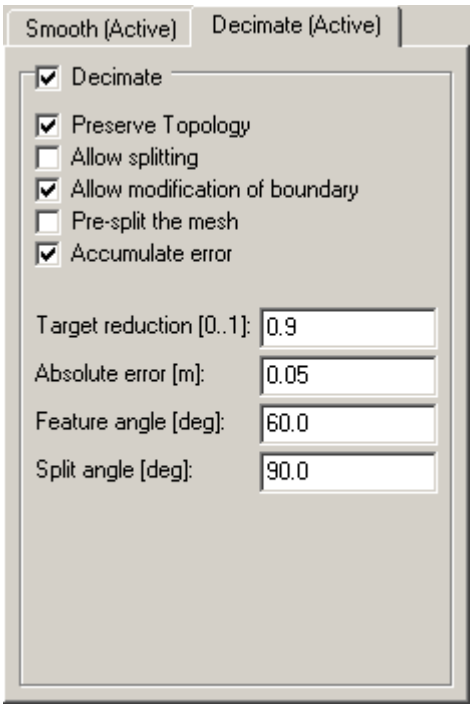
- ***Convergence (*only available with Laplacian smoothing)**

  limits the maximum point motion. If the maximum motion during an iteration is less than the convergence, the smoothing process will terminate.

  Note: if the value = 0, the convergence will be ignored.

Sheet "Decimate"

is a process to reduce the amount of polygons and points in the mesh.



- ***Decimate***

  if this option is active, the settings will be applied to the New data.

- ***Preserve topology***

  a condition for the smoothing algorithm. If enabled, the mesh splitting and hole elimination will not occur.

  Note:
  a greater smoothing (reduced mesh) may be achieved, if the topology does not have to be preserved

- ***Allow splitting***

  if enabled, the mesh will be split at corners, along edges, at non-manifold points or anywhere else a split is required.

  Note:
  Turning splitting off will better preserve the original topology of the mesh, but may not obtain the desired reduction.

- ***Allow modification of boundary***

  if enabled, vertices at boundaries are deleted.

- ***Pre-split the mesh***

  if this option is enabled, the mesh will be split according to the specified split angle, into semi-planar patches, that are disconnected from each other. In some cases, this will produce better results.

- ***Accumulate error***

  to force incremental error update and distribution to surrounding vertices as the mesh is modified. If this option is disabled, the error will be computed directly from the mesh.

  Note: requires additional memory and time to compute.

- ***Target reduction***

  specifies the reduction of the mesh. Because of various constraints, the desired level of reduction may not be achieved. For highest reduction, disable "Preserve topology", set the "Absolute error" to a high value, and enable "Allow splitting" and "Allow modification of boundary".

  Note: a higher value will lead to a greater reduction

  Valid values: 0.1 - 1.0 (default = 0.9)

- ***Absolute error***

  set the highest offset for the coordinates of the points.

- ***Feature angle***

  This angle is used to define edges (i.e. if the surface normal between two adjacent triangles is greater or equal to the feature angle, an edge exists).

- ***Split angle***

  is used to control the splitting of the mesh. A split line exists when the surface normal's between two edge connected triangles are greater or equal to the Split angle.

- ***Restore default***

  all settings will be restored with the default values.

- ***Apply changes to all***

  all the settings and views will be applied to the initial- as well as the new data

- ***Lightsource on/off***

If the settings are complete, initiate the smoothing/decimate process by pressing "Apply changes".

The object will be recalculated according to the settings and show the results in the New Data window (bottom). To save the new data, click "OK". This will apply the changes and save the created object to the folder "POLYDATA".

Recommend workflow:

First step:
- *Windowed sinc smoothing:* 20 iterations, pass band = 0.086

Second step:
- *Laplacian smoothing:* 200 iterations, feature edge smoothing active, feature angle = 30 deg
- *Decimate:* Rate = 0.6, feature angle = 25 deg

Third step:
- *Decimate:* Rate = 0.7, feature angle = 15 deg

7.3.2 Texture

The texture function joins the scaninformation (polydata, triangulated meshes) with the high resolution photographs.

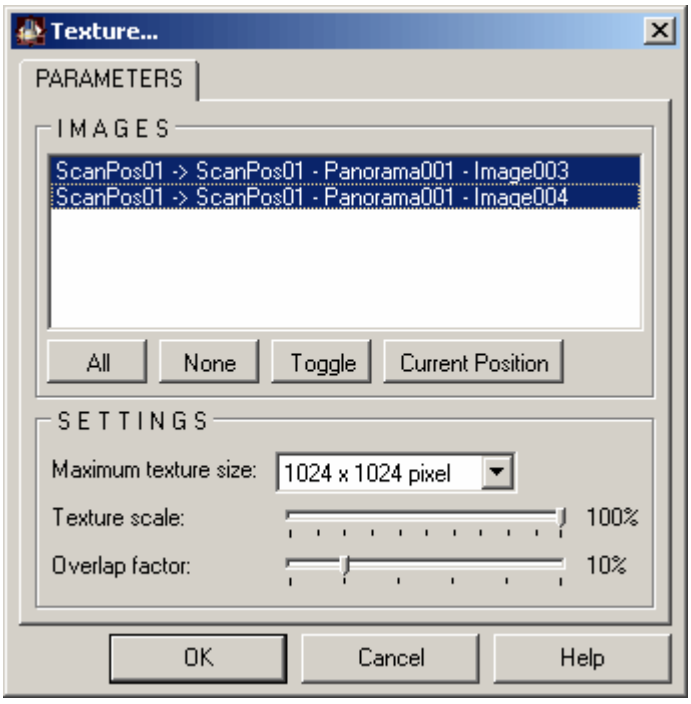
Prerequisites

Images taken by the camera might be slightly distorted by the lens. Before RiSCAN PRO can texture the mesh the images have to be undistorted. To do so please select the desired images, right-click on them and select "undistort" from the menu. All undistorted images will be saved in the folder "UNDISTORTED IMAGES".

Note:
this procedure will also create at least one new camera calibration which will be assigned to the undistorted images. This camera calibration is a copy of the original camera calibration except the lens distortion values. Do not assign this camera calibration to images taken by the camera nor change the calibration values.

Texturing polydata within a scan position

Right-click on the desired polydata object from the folder "POLYDATA" within a scan position and select "Texture..." from the menu.



The dialogs shows a list of all undistorted images of all scan positions. The undistorted images of the scan position the polydata belongs to are selected automatically.

SETTINGS

- *Maximum texture size*

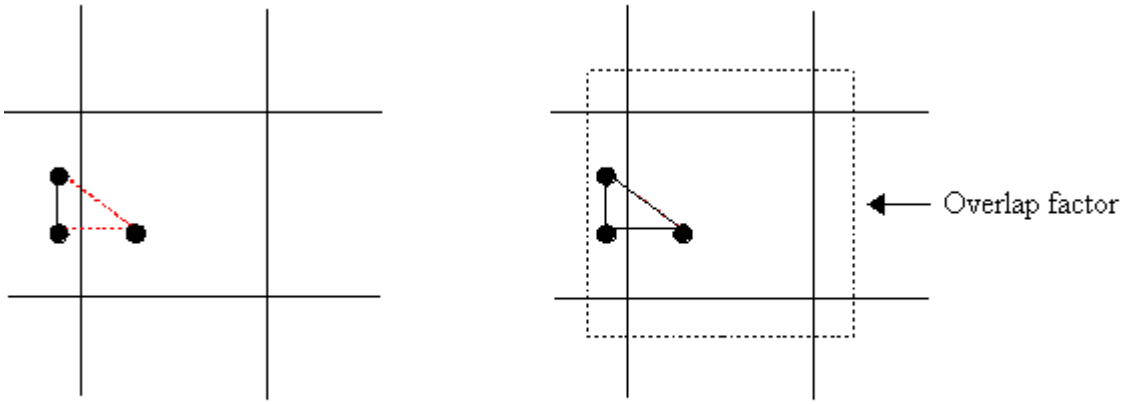
  The images will be split into frames with the selected size (the default value depends on the graphic card - recommended is the highest resolution).

- *Texture scale*

  With this factor you can scale the images before they will be used for the texture process. The default value is 100%. A smaller value leads into less data but also into less quality.

- *Overlap factor*

  Since the images are split into frames (with the size entered before), it's likely that triangles need to be textured with two or more frames, which is not possible. Therefore an overlap factor can be set. The borders of the image-frames will not be strict - the frames will overlap. This will ensure that each triangle can be textured by using just one frame. You'll have to raise the overlap-factor if the mesh you try to texture has rather big triangles (e.g. the mesh was smoothed and decimated - see post process). (default is 10%).



The triangle will not be recognized

The triangle will be recognized and applied with texture

After the texture process has finished a new polydata object will be created (the postfix "_Textured" will be appended to the name). You can view the new polydata object by double-clicking it (see also Object view 102).

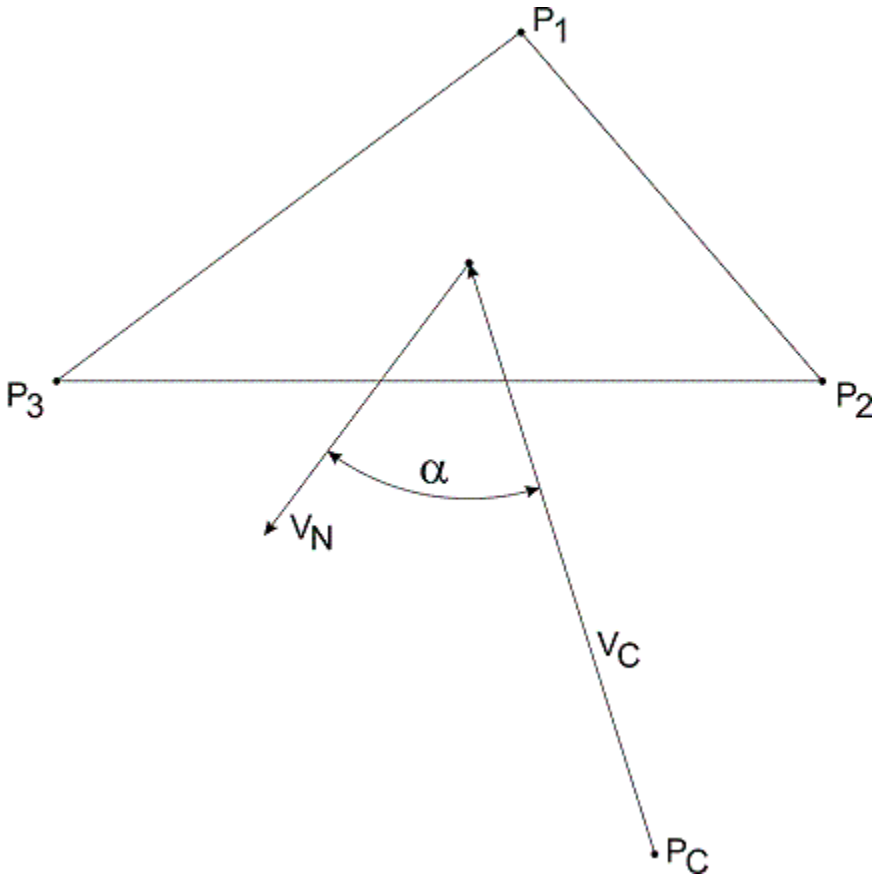
Texturing polydata with the project coordinate system

The method described above is only applicable on single polydata objects located at a scan position. Combined meshes, located at the project coordinate system (folder "OBJECTS/POLYDATA") can also be textured by using undistorted images of scan positions and undistorted free orientated images.

Right - click on the desired polydata object from the folder "POLYDATA" within the folder "OBJECTS" and select "Texture..." from the menu.
A dialog like that shown above will appear. There are two additional parameters:

- *Maximum tilt angle*

  The texturing procedure takes every triangle and tries to find the optimal image to texture it. The image has to meet several criteria such as smallest distance between camera position and center of triangle, visibility of the triangle in image (no other objects between camera position and triangle) and smallest angle of view. With "Maximum tilt angle" you can configure a filter which removes all images where the angle "alpha" between the triangle normal and the ray of sight (see sketch below) is larger than the given value. The higher the angle "alpha" is the less pixels of the image can be mapped on the triangle and thus the worse the quality of the texture will be.



P_1, P_2, P_3...edge points of triangle
V_N...normal vector of triangle

P_C...position of camera
V_C...ray of sight

α ...angle between V_N and V_C

- *Keep untextured triangles*

  Triangles which have no texture at the end of the process will not be present in the resulting mesh. Enable this option in order to keep them.

  Note:
  Not textured triangles will be copied from the source mesh to the new mesh as they are. That means that they will have wrong color or no color information at all.

7.4 Create Orthophotos

RiSCAN PRO offers the possibility to create true orthophotos from scans using the color information from the acquired high resolution images.

For that, two plugins are available:

- Orthophoto plugin 165
  This plugin was developed by RIEGL LMS. It is based on triangulated and textured meshes.

- CityGRID Ortho plugin 168
  This plugin was developed by company GEODATA IT GmbH (www.geodata.at). This plugin does not require meshes because it works on raw scans (3DD files).

Both plugins can be downloaded from the RiSCAN PRO download page 202 and enable the user to create TRUE ORTHOPHOTOS from scan data and image data.

Additionally the module provides also depth information and orientation information in the project's coordinate system to the image data of the orthophoto. This additional information contained in a separate file in a documented format (Description of ZOP file format 198) provides the ability to construct in 3D on the orthophoto in CAD applications, e.g., AutoCAD.

Data generation is conducted by the user by specifying the orientation, position, resolution and size of the frustum of the orthophoto with depth information and the scans images to be used.

The orthophotos will be saved in the folder "OBJECTS/ORTHOPHOTOS" of the project. You can view the orthophoto in a 2D view by simply double clicking on it. To view the orthophoto in a 3D view just drag it from the project manager and drop it onto an opened object view 102.

7.4.1 Orthophoto plugin

1. Undistorting Images

Generation of orthophoto is based on geometry information (scan data) and image data. Before the image information can be applied, the images have to be undistorted. Thus the first step is to undistort the distorted snapshots of the scan position where the scan data are located you intend to use for the orthophoto. To do so, select the images from the directory "SCANPOSIMAGES" you want to undistort and right-click on one image. Select "undistort" from the context menu. Now all selected images will be undistorted using the assigned camera- and mounting-calibrations (this may take some time). The undistorted images will be saved in the folder "UNDISTORTED IMAGES" at the current scan position.

Note:
If you modify either the camera- or the mounting-calibration the already undistorted images get invalid and you must restart the undistort process!

2. Creating meshed data

The second step is to create a triangulated mesh from the single scan you intend to use for the generation of the orthophoto (see Triangulation 150).

3. Texturing the mesh

Texturing a mesh requires a texture mesh AND texture coordinates for every point of the mesh to be textured (see Texture 161).

4. Creating the True Orthophoto

To create a orthophoto open the folder "OBJECTS" of the project structure and right-click on the folder "ORTHOPHOTOS". Select "New orthophoto..." from the context menu. The appearing dialog consists of several steps:

First step:

On the first page of the dialog you can select the meshes you want to use for the orthophoto. After selection

click on the button "Next step >>". The meshes will be loaded and displayed (this may take some seconds).

Second step:

At the second step you can select how the data should be displayed (triangulated/point cloud, truecolor/singlecolor, color of the selected points and color of the defined plane).

Third step:

At the third step you can select points in order to define the projection plane. As an alternative you can load a previously saved plane and use this plane as your projection plane by clicking on the button "Load plane" (see fourth step for information about saving a plane). The camera for generating the orthophoto will be positioned at the center of that plane and is orientated anti-parallel to the normal-vector of the plane.

To select the points within the plane switch to selection mode by clicking on "Selection mode" (or press key "S"). The model will be fixed (no zooming or rotation can be done)

Now you can select the points by drawing a fence. Use the left mouse-button to set the corner points of the fence. Use the right-mouse button to close the fence. After drawing the fence click on the button "Add selected points" (or press key "A") to add the points within the fence. Note, that only points within a certain depth (defined by the deviation value) are selected. Thus, for selecting large areas on a facade, the facade has to be parallel to the imaging plane.
You can repeat the selection process as often as you like.

Finally leave the selection mode by clicking on "Selection mode" (or press key "S") again.

Now you have to decide the orientation - Three different orientations are available:

- vertical orientation

  Intended for generating orthophotos of facades. The plane is strictly in parallel to Z axis of the project coordinate system.

- horizontal orientation

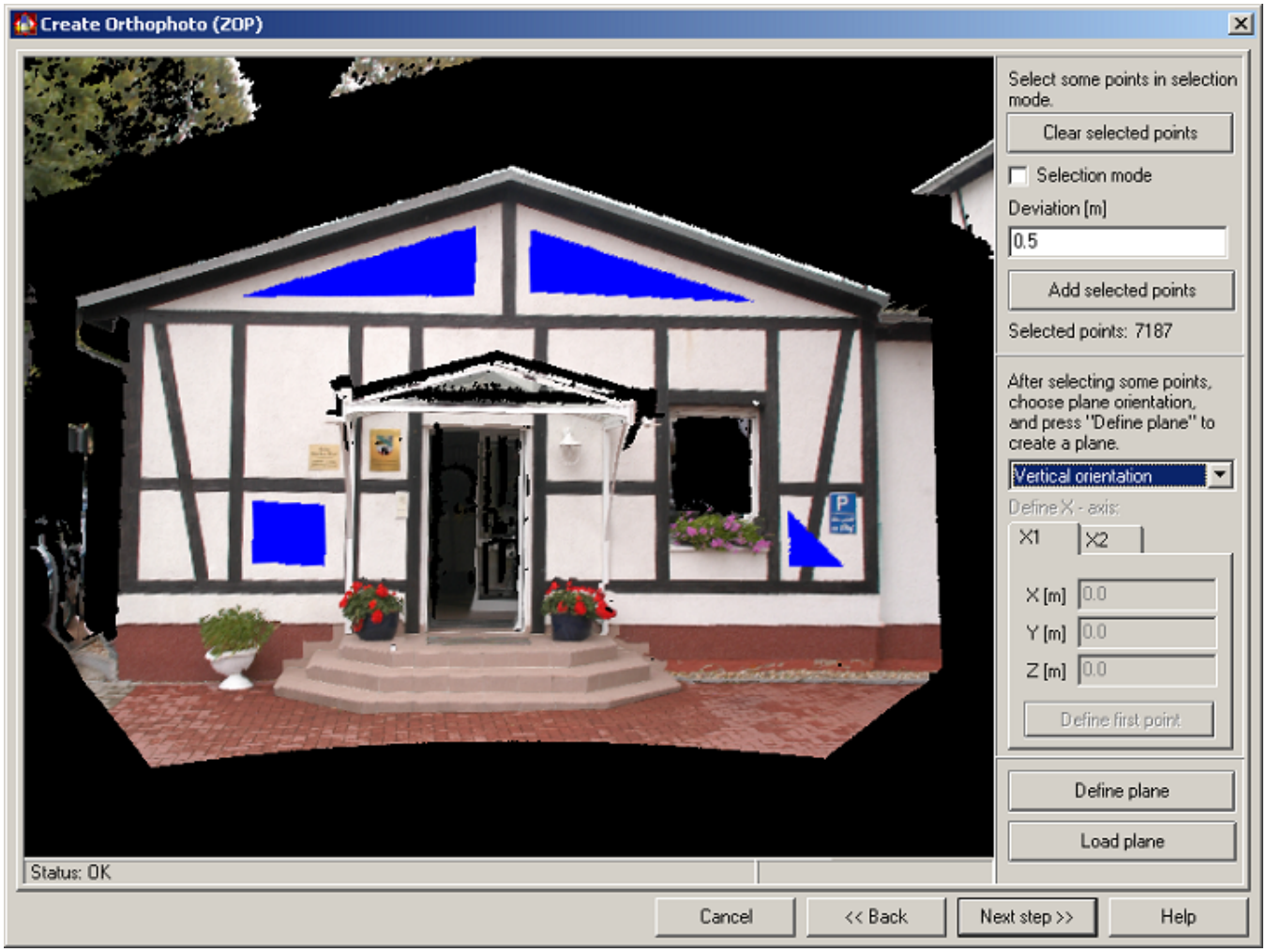
  Intended for generating orthophotos of the floor or ceiling. The plane's normal vector is parallel to Z-axis of the project coordinate system. The X-axis has to be defined (see "free orientation").

- free orientation

  In this mode you have to define the X-axis by two points (X1 and X2). To do so click on the button "Define first point" (X1) and click on the corresponding point in the 3D-scene. Proceed this way with the second point (X2).

Finally calculate the projection plane by clicking on "Define plane". The plane position, size, and orientation will be calculated and the plane is displayed.

A screenshot of step three:



Fourth step:

At the fourth step you can modify the projection plane's position and size.
Just edit the input fields "Plane width" and "Plane height" and click on the button "Apply dimension changes".
To change the position of the plane use the cursor-buttons. The offset used for changing the position can be entered in the input field "Additional constant". Each time you click on one of the cursor-buttons the plane will be moved by that offset in the selected direction.
Finally you can save the plane in order to use it again for other orthophotos. Just click on the button "Save plane" and enter a name for the plane in the appearing dialog (Saved planes can be used in the third step).

Fifth step:

At the fifth step you can define the near plane and the far plane. These planes are parallel to the projection plane. The values you enter are the distances (along the normal vector) between the projection plane and the near plane and the projection plane and the far plane. Only triangles with all three edges between near- and far-plane will be used for the orthophoto.

Furthermore you can modify the so-called "Offscreen resolution". An offscreen resolution about 0.01 (=default) means that one pixel of the created orthophoto will represent one centimeter. Note, that smaller values will increase the size of the orthophoto and due to this the calculation time will increase enormous).

Now RiSCAN PRO has got all information it needs to create the orthophoto, so click on the button "Create orthophoto".
The orthophoto will be created (this may take some time, depending on the size) and saved in the folder "ORTHOPHOTOS" (folder "OBJECTS") with the name "OrthoPhotoXYZ" (XYZ is an consecutive number).

7.4.2 CityGRID Ortho plugin

1. **Undistorting Images**

   see "Orthophoto plugin: Undistorting images 165"

2. **Open or create an object view**

3. **Add data (scans, 3DD files)**

   Since the scan is only needed to define the projection plane (step 4) you can also add a different scan instead of the scan(s) used for the orthophoto. The scans used to create the orthophoto are defined at step 6.

   Note: This plugin only handles scans. Polydata objects can not be used!

4. **Create the projection plane**

   This plane defines the orientation, position and size of the orthophoto (see "Create geometry objects: Plane 173").

5. **Save the project**

   It's necessary to save the RiSCAN PRO project before you can start CityGRID Ortho because the module works directly on the project file.

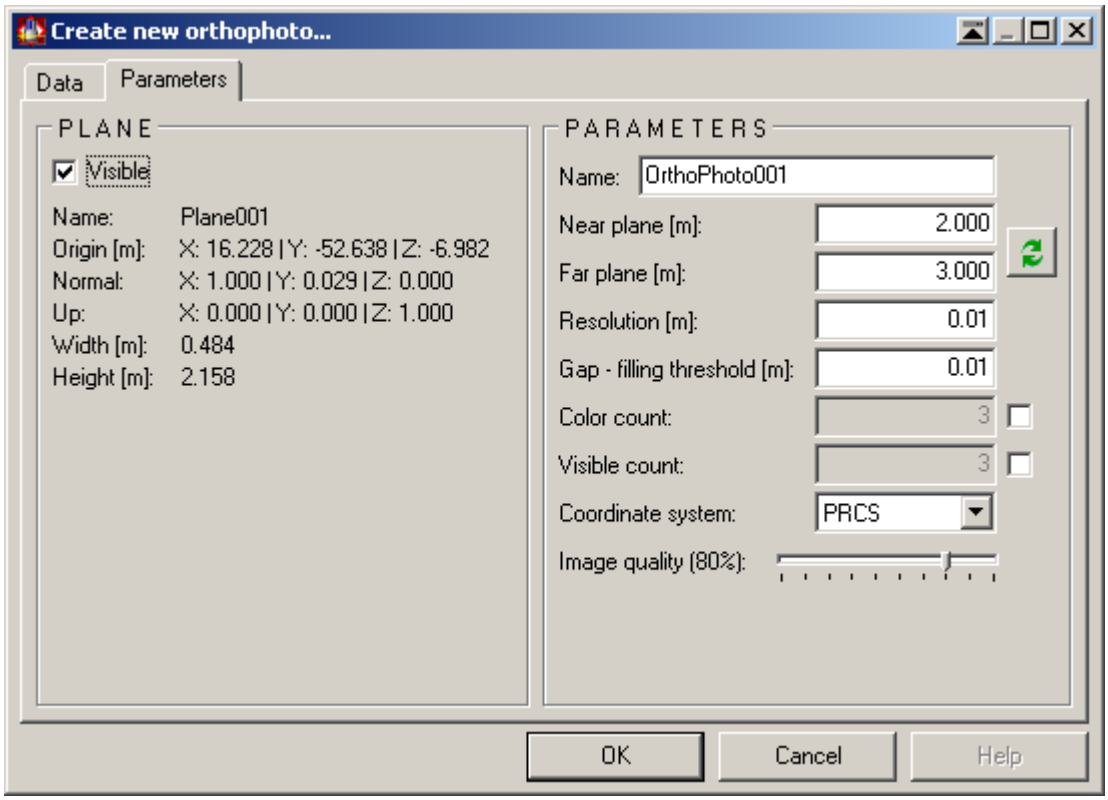
6. **Start CityGRID Ortho:**

   Click with the right mouse button onto the projection plane in the object inspector and select "New orthophoto (CityGRID Ortho)..." from the menu. The configuration dialog appears. The dialogs consists of two pages:

   - **Data**

     On this page you can select which scans and images should be used to create the orthophoto. The tree view on the **left side** shows all scans of the project, whereas the scans present in the object view are already selected. You may select additional scans here. The tree view on the **right side** shows all images of the project, whereas the images of the same scan positions as the selected scans are already selected (this state can be restored by pressing the button with the blue arrow pointing downwards). You may select more images here.

   - **Parameters**



The **left side** of the dialog shows a summary of the parameters of the used projection plane. Activate or deactivate the option "Visible" in order to show or hide the plane in the corresponding object view.

Hint: When you click on the fourth button from left in the title bar of the dialog, the dialog is minimized in order to give a better view of the object view. Click again on this button to restore the dialog.

The **right side** of the dialog shows the parameters needed for the creation of the orthophoto:

- **Name:**

  The name of the orthophoto to create.

- **Near plane & Far plane:**

  These planes are parallel to the projection plane. The values you enter are the distances (along the normal vector of the projection plane) between the projection plane and the near plane and the projection plane and the far plane. Only triangles with all three edges between near- and far-plane will be used for the orthophoto. Click on the button beside the input fields to update the 3D scene in the object view.

- **Resolution:**

  The resolution of the orthophoto. That is the size of one pixel of the orthophoto.

- **Gap - filling threshold:**

  Before the orthophoto is created the scan data is triangulated. This value determines to which extend gaps should be closed.

- **Color count & Visible count:**

Both parameters are used to restrict the number of images for the visibility calculation during the texture procedure. Per default all images are used. To change this activate the checkboxes behind the input fields. The higher these values are the longer the calculation procedure will last.

- **Coordinate system:**

  The coordinate system in which the orthophoto should be saved.

- **Image quality:**

  The orthophoto is saved as JPEG image. This factor determines the compression quality of the image (0..100%, default 80%).

To finally create the orthophoto click on the button "OK". The orthophoto will be saved in the folder "OBJECTS/ORTHOPHOTOS".
For further information about this module please contact company GEODATA IT GmbH: www.citygrid.at or office@geodata.at

7.5 Create geometry objects

This chapter describes how to create geometry objects based on geometry data (scans, polydata,...) loaded into an object view 102.

- Create or open an object view
- Add the objects of interest
- Click with the right mouse button into the view window and select the menu item "New object" which offers a submenu with following items:

  - Point... 171
  - Polyline... 171
  - Sphere... 173
  - Plane 173
  - Section... 176
  - Tiepoint... 177

As an alternative you can also click on a button of the toolbar "3D - New object" (use the view menu 14 to show the toolbar):

(the functions described above are ordered from left to right on the toolbar)

The parameters needed to create the geometry objects are described in the subsequent sections.

Common options:

- 3D Point definition via mouse:

  Most objects need to define at least one point. This is done interactively by holding the shift key and clicking near a point in the 3D scene. To determine which point of the scene should be used two different modes can be selected:

  1. **Closest point**

     When you click into the 3D scene, the closest point to the ray-of-sight is searched.

Note:
Only points of loaded and visible datasets will be used. The search may take some time when the view contains a lot of data.

2. **Point on surface**

   When you click into the 3D scene, the point is calculated as the intersection point between the ray-of-sight and the triangle or plane with the smallest distance to the current viewpoint.

Note:
Almost all geometry objects who need at least one point defined, offer the option to enter the coordinates directly. The coordinates displayed and entered always belong to the coordinate system currently selected in the object inspector 108.

- Shortcuts:

  Some of the "create new objects" dialogs have keyboard shortcuts (define point 1, define point 2, create,...). These shortcuts are only functional, when the object view window has the input focus. To set the input focus just click with the left mouse button into the object view window.

7.5.1 Point

Create point from geometry data:

1. Open the "New object..." dialog to create a point as described in "Create geometry objects 170".
2. Define the point with the mouse 170 or enter the coordinates directly. When you enter the coordinates directly click on the button beside the coordinates in order to update the position of the point displayed in the 3D scene.
3. To finally create (save) the point click on the button "Create point" or press the key "3". The point will be saved in the folder "OBJECTS/POINTS" and added to the current object view.

Create point object from intersection between a Polyline and a plane:

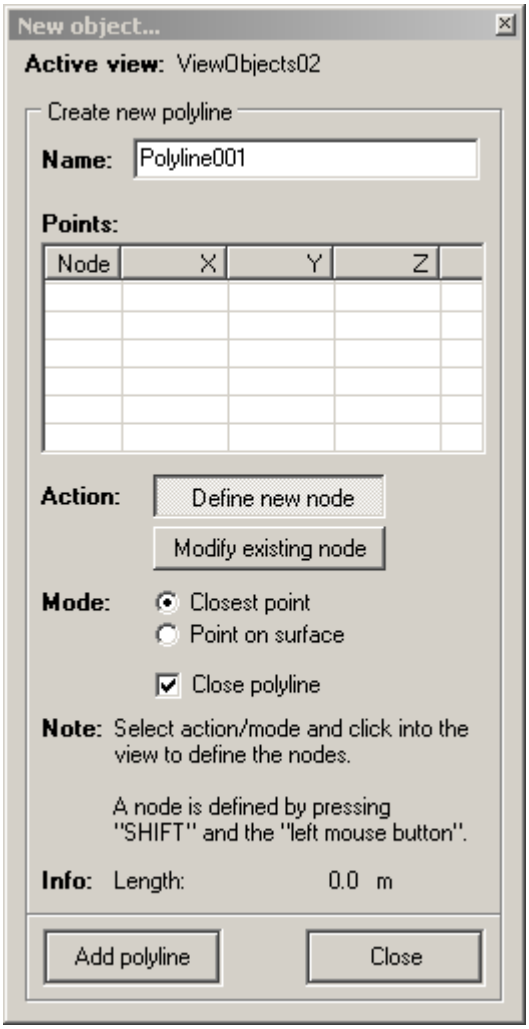
1. Open/create an object view and load the data you want to work with.
2. Select a polyline and a plane in the object inspector.
3. Open the popup menu of the plane and select "Intersect" in order to create and a new point object.

Note:
An intersection only occurs if a line segment of the polyline intersects the plane.
If the polyline has only one line segment this segment is treated as ray and therefore the intersection point does not need to lie within the segment.

7.5.2 Polyline

Create polyline from geometry data:

1. Open the "New object..." dialog to create a polyline as described in "Create geometry objects 170":



2. Click on the button "Define new node" or press key "1".
3. By defining a point 170 a new polyline node will be added. The new node will be displayed in the list.
4. Repeat step 3 until all nodes of the polyline are defined and continue with step 5.
5. To create a closed polyline (=polygon) enable the option "Close polyline"
6. To modify a polyline node, select the node in the list, click on the button "Modify existing node" (or press key "2") and re-define the point 170. Instead of adding a new node the coordinates of the selected node will be modified.
7. To finally create (save) the polyline click on the button "Add polyline" or press key "3". The polyline will be saved in the folder "OBJECTS/POLYLINES" and added to the current object view.

Create polyline from tiepoints:

Open a tiepoint list and select some tiepoints. Then open the popup menu and select "Create geometry object…/ Polyline".

Note:
At least 2 tiepoints must be selected in order to create a polyline.

Create polyline from point objects:

Select some point objects in the project manager and open the popup menu. Select "Compose polyline" in order to create a polyline.

7.5.3 Sphere

1. Open the "New object..." dialog to create a sphere as described in "Create geometry objects 170":
2. Define the center point of the sphere by either defining a point with the mouse 170 or enter the coordinates directly. When you enter the coordinates directly, click on the button beside the coordinates in order to update the position of the sphere in the 3D scene.
3. Define the radius of the sphere by moving the mouse or enter the radius directly. When you use the mouse the action "modify radius" must be activated (press key "1" to do so). When you enter the radius directly, click on the button beside the coordinates in order to update the radius of the sphere in the 3D scene.
4. To finally create (save) the sphere click on the button "Create sphere" or press the key "3". The sphere is saved in the folder "OBJECTS/SPHERES" and added to the current object view.

   Note:
   If "Modify radius" is activated the radius is modified everytime you move the mouse. To be a able to click on the button "Create sphere" you have to deactivate this option first. To do so press the key "2".

7.5.4 Plane

Create plane from geometry data:

To create a plane please proceed as follows:

1. Open or create an object view
2. Add the objects of interest
3. Click with the right mouse button into the object view and select "New object/Plane" from the menu. As an alternative you can also use the corresponding button of the toolbar "3D - New object" 170. When you click on this button for the first time a menu is opened offering the functions described below. This menu can also be opened when you click on the small arrow beside the button. When you have selected a function and you click on the plane button the next time, the same function will be executed.

   - **Co-planar with the x-y plane**
     This will create a plane parallel to the x-y plane of the currently selected coordinate system.
   - **Co-planar with the x-z plane**
     This will create a plane parallel to the x-z plane of the currently selected coordinate system.
   - **Co-planar with the y-z plane**
     This will create a plane parallel to the y-z plane of the currently selected coordinate system.
   - **From 1 point**

With this function you can create the plane by defining just one point. This point will be the origin of the plane. To define this point use the mouse 170 or enter the coordinates directly. When you enter the coordinates directly click on the button beside the coordinate in order to update the plane in the 3D scene. The orientation of the plane is defined via the orientation of the virtual camera (the plane will be aligned normal to the direction of the virtual camera). If you want to navigate in the scene without modifying the orientation of the plane, activate the option "lock plane normal". To tilt the plane about 180° deg activate the option "Negate normal vector". To finally create (save) the plane click on the button "Create plane".

- **From 2 points**
  This mode is only available when the camera is set to orthogonal mode 108.
  With this mode you can define a plane by defining two points. These points define an axis which lies within the plane. The rotation of the plane about this axis is determined by the orientation of the virtual camera (the plane normal will be normal to the direction of the camera).
  As soon as you enter this mode the navigation is locked (you can not pan, rotate or zoom). To define the points of the axis click with the left mouse button into the view. After you have defined the second point the plane will be created immediately.

  The dialog of this function offers some tools to make axis definition easier:
  Orientation
  - **Free** - the axis can be defined in any direction
  - **Horizontal** - the axis can be defined horizontally only
  - **Vertical** - the axis can be defined vertically only

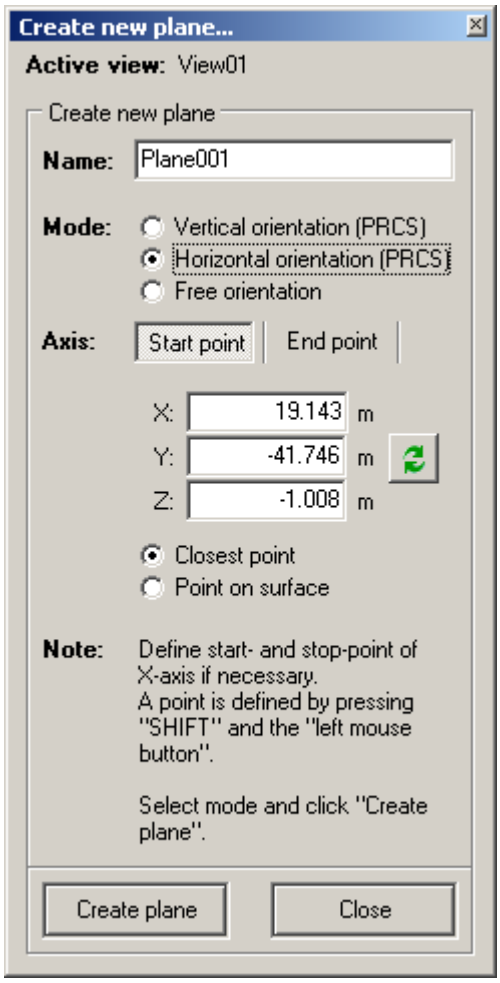
  Note: "Horizontal" and "Vertical" are related to the screen

  Orientation relative to previous
  - **Parallel** - the axis will be defined parallel to the previous
  - **Perpendicular** - the axis will be defined perpendicular to the previous

  To leave this mode click on the button "Close".

- **From selected area**
  Before you can use this function select some points 143 in the object view. The function will create an unlimited plane that is calculated by the least-squares-fit algorithm from the coordinates of the selected area. The plane will be displayed limited only by the bounding box of the object view.

- **From selected area (limited)**
  Creates a plane like the function described above. Additionally the orientation of the plane can be set:



- Vertical orientation

  Intended for generating orthophotos of facades. The plane is strictly in parallel to Z axis.

- Horizontal orientation

  Intended for generating orthophotos of the floor or ceiling. The plane's normal vector is parallel to Z axis. The X axis has to be defined (see next mode: "Free orientation").

- Free orientation

  In this mode you have to define the X axis (bottom edge of the plane) by two points ("Start point" and "End point"). To do so click on the button "Start point" (or press key "1") and click on the corresponding point 170 in the 3D scene. Proceed this way with the second point ("End point", key "2"). As an alternative you can also enter the coordinates of the two points directly. In that case click on the button beside the coordinates in order to update the axis in the 3D scene. To finally create the plane click on the button "Create plane".

Note: All 3 modes always use the currently selected coordinate system 108 (either PRCS or GLCS).

The created plane is saved in the folder "OBJECTS/PLANES" and will be added to the current object view.

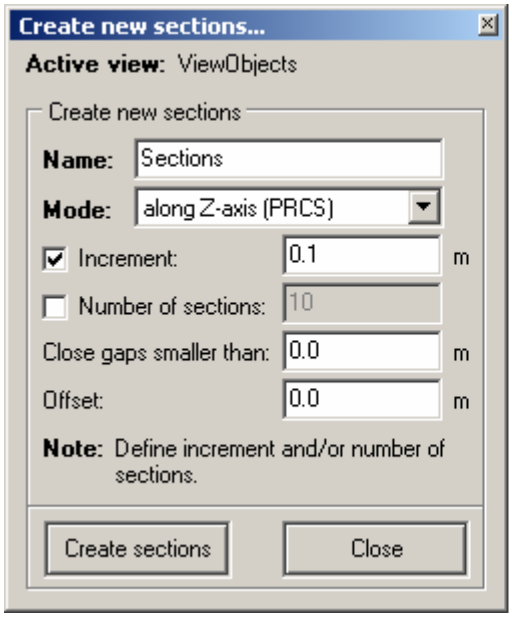
Create plane from tiepoints:

Open a tiepoint list and select some tiepoints. Then open the popup menu and select "Create geometry object…/ Plane".

Note:
At least 3 tiepoints must be selected in order to create a plane.

7.5.5 Sections

You can create cross sections from triangulated data (Polydata), by viewing the data of interest in an object view. You may also select only a part of this data. Then click with the right mouse button in the object view and select "New object..." -> "Sections".



Select prefix of resulting sections.

Select creation mode.

Select increment between two sections.

Select number of sections.

Select distance for gap closing.

Select offset.

Mode:
Some modes to determine the orientation of the sections are available:

- **Along X, Y, Z – axis:**
  Create parallel cross section(s) along one of the three coordinate axes. The coordinate system is defined by the object inspector 108 (SOCS, PRCS, GLCS).

- **One plane:**
  Create cross section(s) parallel to one plane.

- **Two planes:**
  Create cross section(s) between two parallel planes.

Note:
The modes "One plane" and "Two planes" need additional information about the plane(s) to use. To define which plane(s) to use select them in the object inspector.

Increment:
Defines the increment between two sections.

Number of sections:

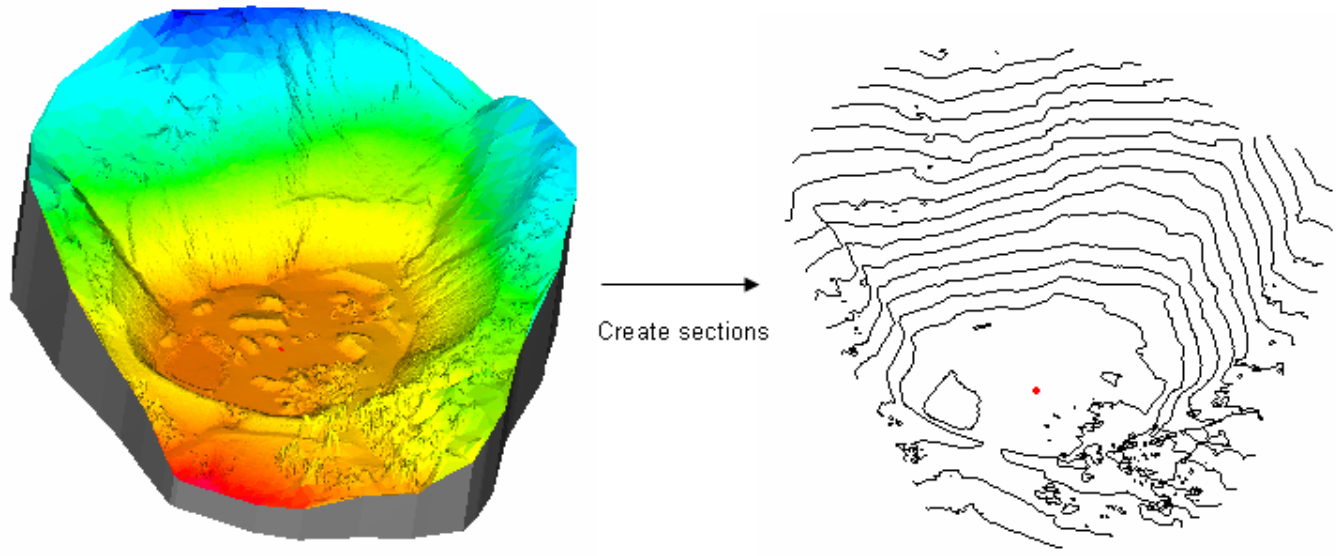
Defines the number of sections to generate

Close gaps smaller than:
You can close gaps within a section by defining this value larger than zero. The gap will be closed with a straight line connecting the two intersection points surrounding the gap.

Offset:
This value is used to determine at which level (counting from the reference plane) the first section should be created. The reference plane depends on the selected Mode. The modes using a coordinate axis use the plane normal to the axis and starting at the origin of the coordinate system. The modes using planes use the specified plane as reference.

Note:
At least one value "Increment" or "Number of sections" must be defined. When you specify just one value the other one is calculated automatically (but not displayed) using the complete range given by the data.

Example: Cross sections with 7.5m increment



7.5.6 Tiepoint

Creating tiepoints is similar to creating points 171.
In addition to the other parameters you can also define the reflector calibration of the tiepoint. To do so select the calibration from the list "Type" before you create the tiepoint.

To finally create (save) the tiepoint click on the button "Create tiepoint" or press key "3". The new tiepoint will be saved in the corresponding tiepointlist of the selected coordinate system 108 (that means either TPL GLCS, TPL PRCS or the TPL SOCS of the selected scan position).

7.6 Measurements

This chapter describes how to measure point coordinates, distances, volumes and surface areas in an object view 102.

- Create or open an object view
- Add the objects of interest
- Click with the right mouse button into the view window and select the menu item "Measure" which offers a

submenu with following items:

- Point coordinate... 178
- Distance between two points... 178
- Volume and surface area... 180

As an alternative you can also click on a button of the toolbar "3D - Measure" (use the view menu 14 to show the toolbar):

(the functions described above are ordered from left to right on the toolbar)

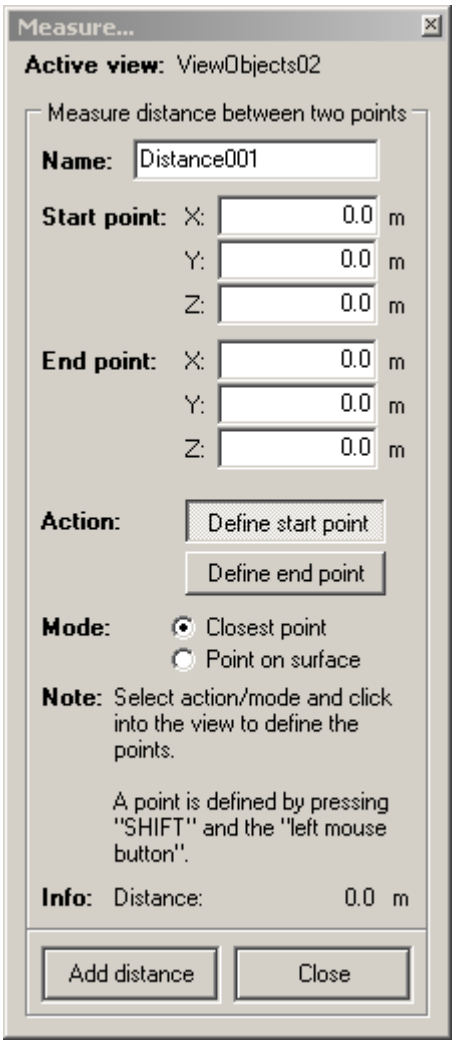
The functions are described in the subsequent sections.

7.6.1 Measure point coordinates

See Create geometry objects: Point 171.

7.6.2 Measure distance

- *distance between two points*



MEASURE DISTANCE BETWEEN TWO POINTS

Mode

- *Closest Point*

  the nodes will be defined with the coordinates from the closest point available

- *Point on surface*

  the nodes will be defined with the coordinates from the cursor when the mouse-button is pressed.
  Note: the mouse has to be positioned within a surface when the button is pressed!

Shortcuts (the focus has to be on the view, so the shortcuts should be applied during the definition of the points)

- press key 1 -> activate "Define start point"
- press key 2 -> activate "Define end point"
- press key 3 -> "Add distance"

When a distance is added, there will be a new object within the directory "DISTANCE" in the Object-Inspector window.

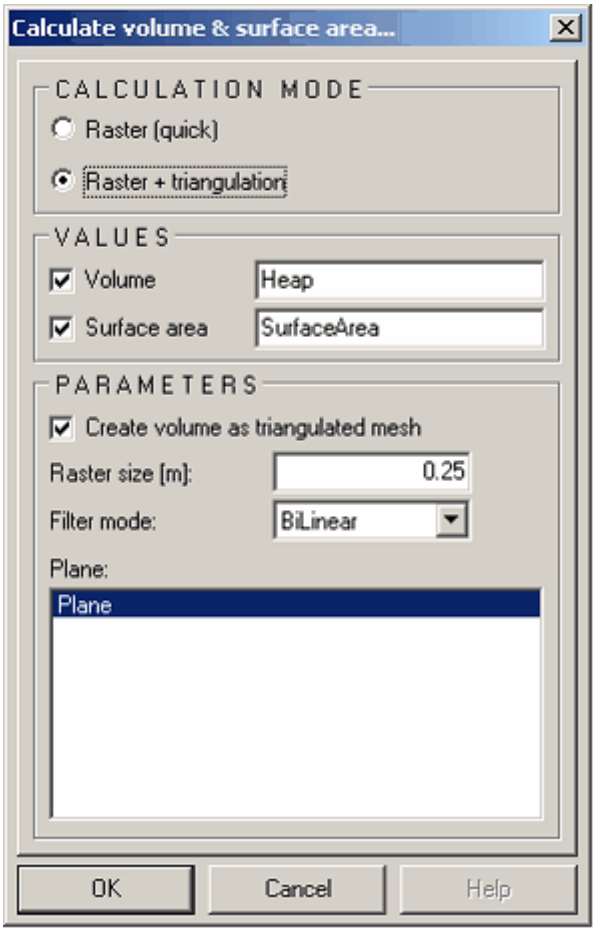
Note:
if the created distance is not visible, select the distance-object from the Object-Inspector window and increase the "Line width" in the Properties window.

7.6.3 Measure volume and surface

You can calculate the volume and the surface area from various data (scans, polydata) by loading the data in an object view and defining a reference plane. This plane is used to map the selected data onto it. It is also a clipping plane. That means that only data is used, which is above this plane.

After defining the plane you can start the calculation process by locating the plane in the object inspector and right-click on it with the mouse. Then you have to select "Calculate volume & surface area..." or you right-click with the mouse in the object view and select "Measure" -> "Volume & surface area...".

When you do so the following dialog appears:

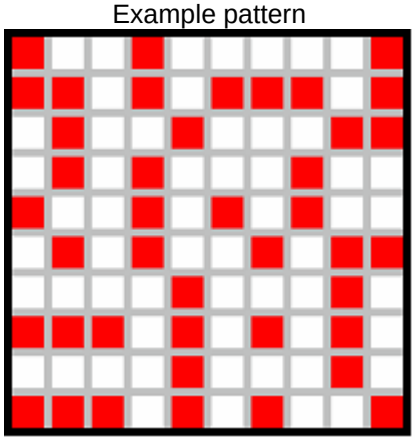


CALCULATION MODE

In this section you can select which calculation mode should be used:

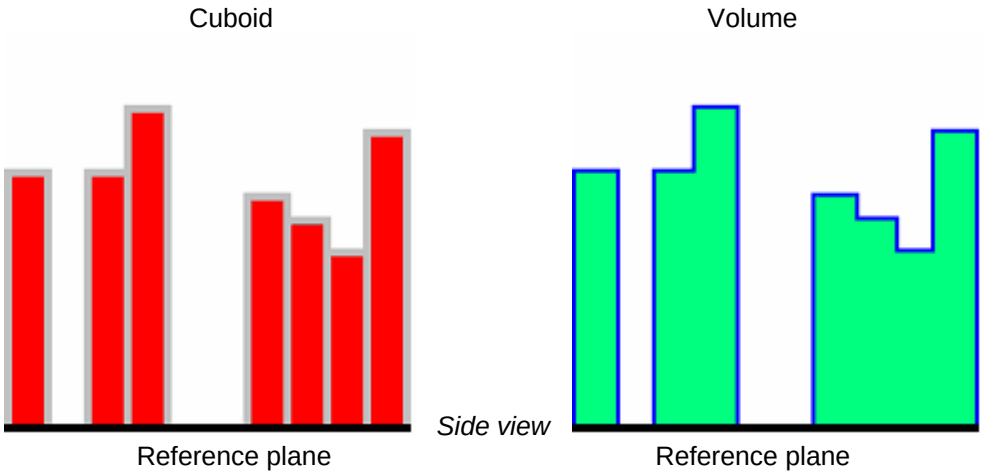
In both calculation modes the data is filled into a pattern, which is defined by the raster size (see also section parameters).

Example pattern



- **Raster**

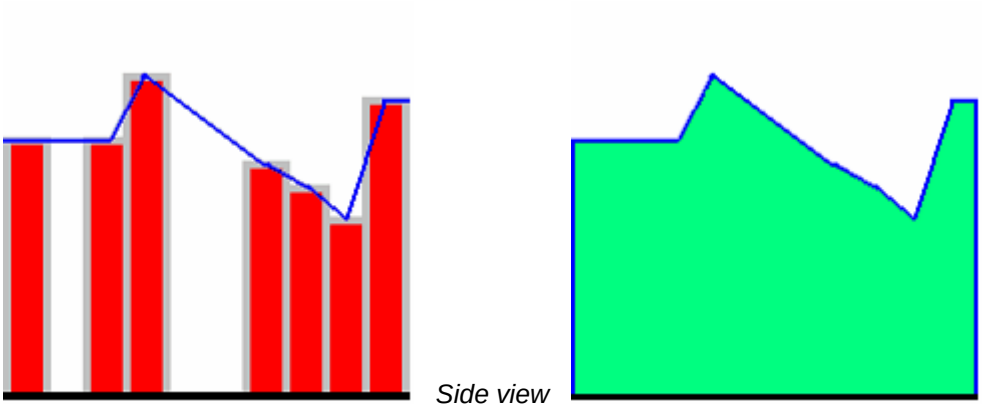
  This is a fast way to calculate the volume, but the result is not very exact.
  For every cell the volume of the according cuboid is calculated. As result all cell volumes will be added. If a cell is empty no volume can be calculated for this cell. So you must adjust the raster size so that every cell is filled with a value.



- **Raster + triangulation**

  All raster points will be triangulated with a 2D-Delaunay triangulation algorithm. The Delaunay triangulation is computed from the 2D coordinates of the vertices mapped onto the reference plane. The volume is calculated between the plane and the resulting surface.

Surface Volume



VALUES

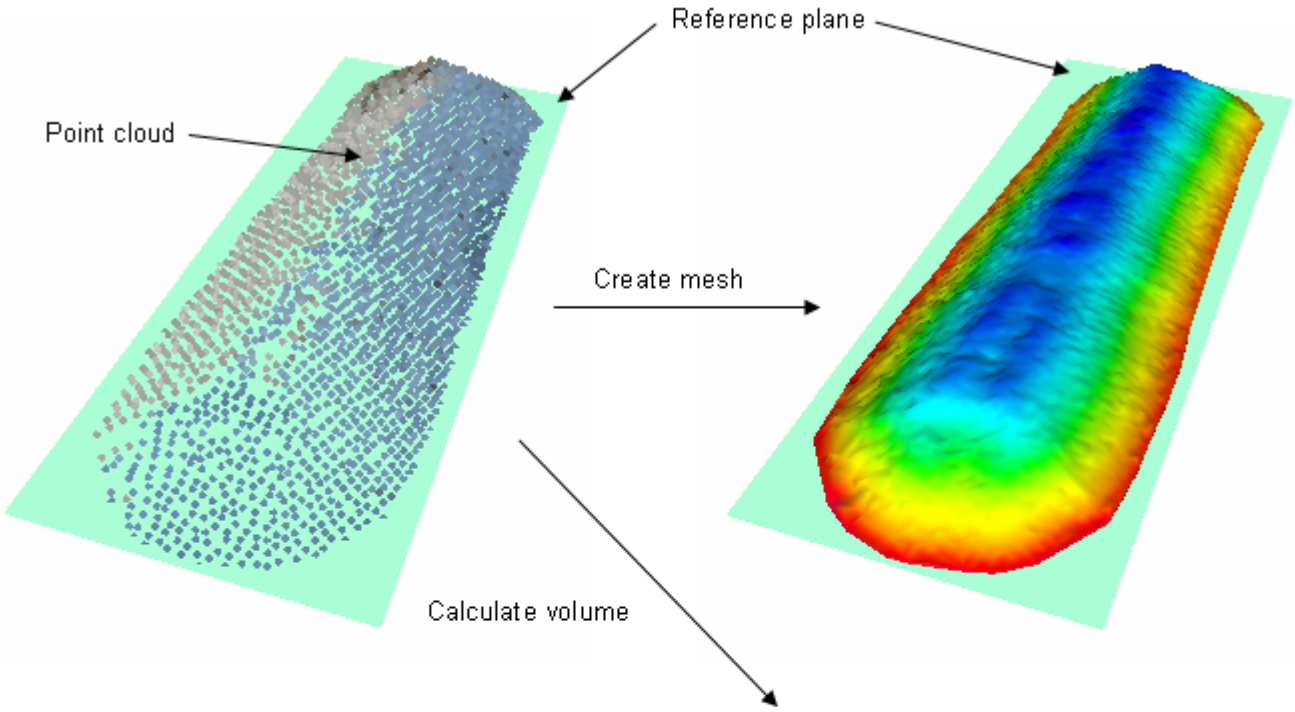
In this section you can select which values (results) should be calculated ("Surface area" is only available in triangulation mode). Beside the checkboxes you can enter the name for the value.

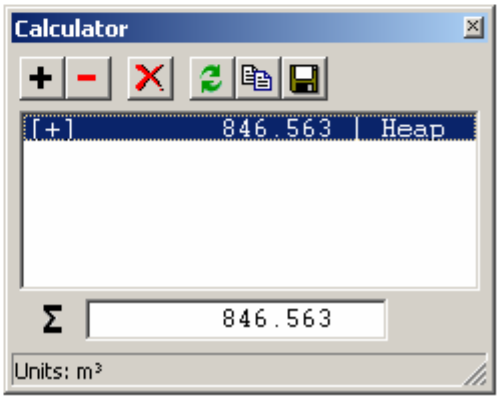
PARAMETERS

Create volume as triangulated mesh	when you activate this option a polydata object will be created containing the triangulated surface.
Raster size	select raster size of pattern.
Filter mode	select filter mode for calculation.
Plane	select reference plane.

In the "BiLinear" filter mode all the input points will be averaged in every cell of the pattern. In the "Min" / "Max" filter mode only the point with the smallest/largest normal distance to the reference plane is filled into the cell.

Example:


Reference plane
Point cloud
Create mesh
Calculate volume

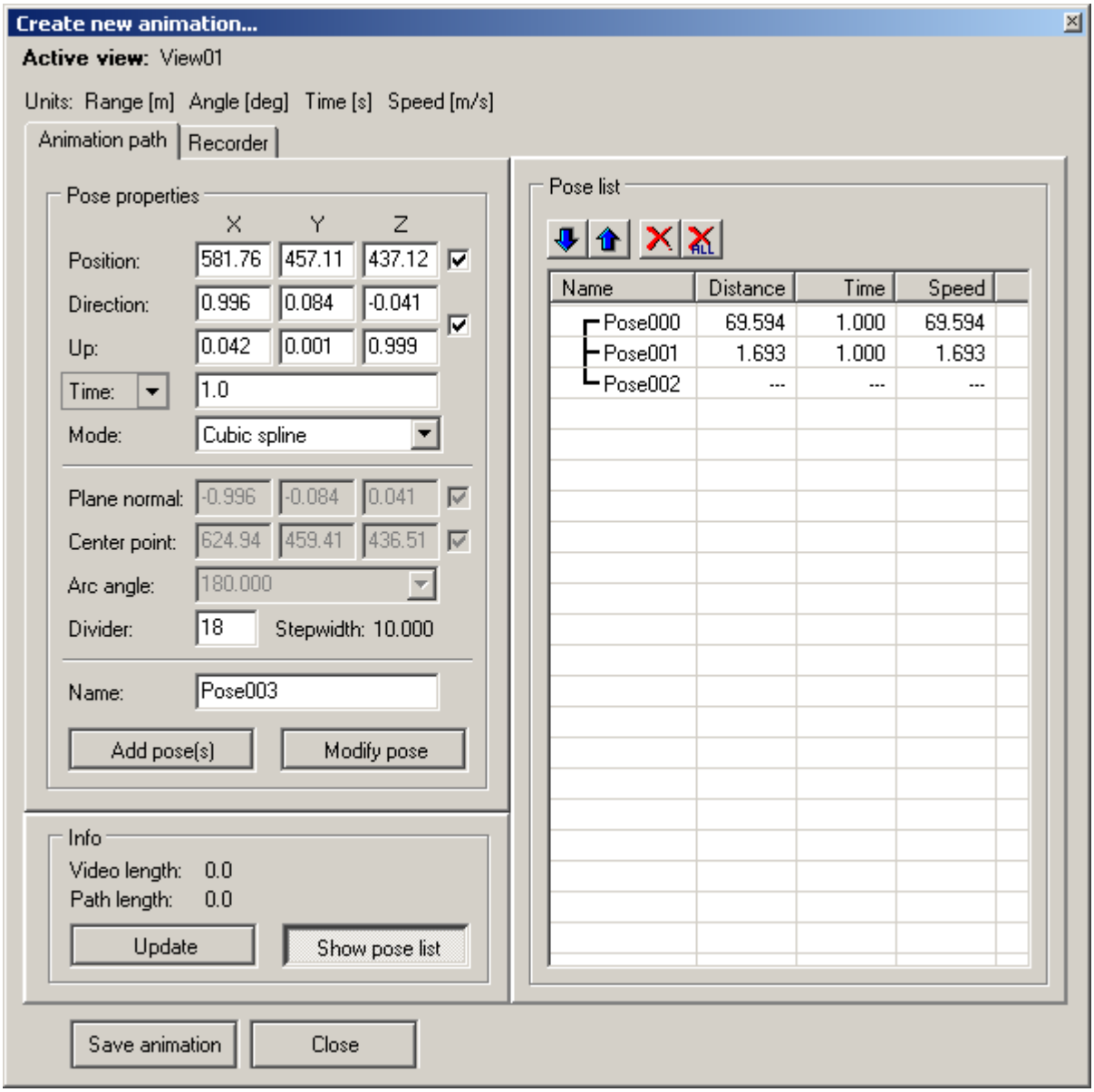

Calculator
[+] 846.563 Heap
Σ 846.563
Units: m³

7.7 Animations

The object view within RiSCAN PRO has the ability to produce animations of the 3D scene it displays. The animation is based on user defined camera positions and camera orientations (called "pose"). The camera path between two poses is calculated by RiSCAN PRO in order to get a fluently camera movement. The created animation can be saved as AVI file whereas all installed video codecs can be used to compress the video file.

Step by step description:

1. Open or create an object view. To get better results, make sure, that the parameter "Scene scale" of the camera of the view is set to 1.
2. Add all objects (scans, polydata, planes, polylines,...) of interest to the object view and configure their attributes (color, draw mode).
3. Click with the right mouse button into the object view window and select "Create new animation..." from the menu. The following dialog will appear:



4. The next step is to define the animation path. The animation path may consist of several parts. Each part is build up by two poses, a travel mode and the duration.

The **two poses** define the start and stop position and orientation of the virtual camera. All parts of the animation path are stringed together. That means, that the stop pose of the previous part is the start pose of the current part.

The **travel mode** defines how the path between start and stop poses should be calculated. Following modes are available:

Linear interpolation
Start and stop pose will be connected by a straight line. No acceleration or deceleration of the movement will be done.

Cubic spline
This mode calculates a smooth curve which connects all poses of the animation. Also the speed of the flight is varying.

Arc
With this mode you can configure a constant movement of the camera along an arc. The movement will be simulated by several subparts with mode "Cubic spline"

To control the **duration** of the travel from start pose to stop pose you can either define the speed or enter the time directly.

How to define a "linear" or "cubic spline" camera movement

Navigate within the object view to the start point of this part of the animation (the pose properties "Position", "Direction" and "Up" will be updated automatically each time you move the virtual camera). As an alternative you can also enter the coordinates and vectors directly.

Define the duration of the movement. This is done by either selecting "Time" or "Speed" and entering the speed of the movement or the time the movement should take.

Select Mode "Linear interpolation" or "Cubic spline"

Leave all other settings unchanged and click on the button "Add poses(s)"

Splitter:
You can define splitters in order to split the animation path. This may be helpful when defining cubic spline movements. Because all nodes of a cubic spline path have influence on the complete path and may lead to a wird movement of the camera.

How to define a camera movement along an arc

Navigate to the start point of the arc. As an alternative you can also enter the coordinates and vectors directly. To get better results, the camera should look approximate to the rotation center. Uncheck the checkbox behind the pose properties "Position", "Direction" and "Up". This will leave the values unmodified when you move the virtual camera.

Now you have to define the **normal vector of the plane** the arc should lie in. The normal vector can be defined by the direction of the virtual camera. Example: If you want to "fly" around and vertical aligned object you may use the bird's eye view to define the normal vector of the plane. Uncheck the checkbox behind the pose property "Plane normal" to avoid unwanted modification of this vector.

The next step is to define the **rotation center**. This is done by simply clicking into the scene. The rotation

center will be marked with the pickpoint (default is a red pixel). Uncheck the checkbox behind the pose property "Center point" to avoid unwanted modification of this point.

Define the **arc angle**. For a full rotation of the scene you have to enter 360 deg

As mentioned above, the movement will be built up by generating a number of poses lying on the arc with mode set to "Cubic spline". With **Divider** you can decide how many poses are created. As a thumb rule you can set this value that way, that the rotation between two poses is approximately 10 deg (a Divider of 18 for 180 deg arc angle).

Define the duration of the movement. This is done by either selecting "**Time**" or "**Speed**" and entering the speed of the movement or the time the movement should take. Note, that the time parameter is set for each created pose and not for the complete arc!

Finally click on the button "Add poses(s)".

How to edit the poses

Click on the button "**Show pose list**" to show a list of all defined poses. To delete a pose select if from the list and click on the button "Delete pose" with a red X on it.
To modify a pose double click on it in the list. The virtual camera position and orientation will be set according to the pose. Now you can modify the parameters either by moving the virtual camera or by entering the parameters directly. When all modifications are done click on the button "**Modify pose**".

To change the camera orientation of some poses, select them and right-click. Choose "Change orientation" from the popup menu.
A new dialog will be opened and you can enter an angle to rotate around the three axes. You must also define the last pose, where the rotation should end.

The complete camera path will be displayed in the scene by a white line. The poses will be represented by small red spheres on the line.
To save the animation path click on the button "**Save animation**". You will be asked for a name. The animation path will be saved in the folder "COLLECTIONS/ANIMATIONS" within the project.

5. Animation playback (simulation)

Change to the page "Recorder". To get an impression of the final animation click on the button "**Simulate**" and select "**Simulate with camera**" from the menu. This will start the playback of the animation. Note, that the speed of this preview does not necessary correspond with the speed of the final (recorded) animation. Especially when the object view contains a lot of data the speed of the preview is much slower than the speed of the resulting animation.
The speed of the complete animation (not of several animation parts) can be modified with the "**Time multiplier**". The default value is 1. To get twice animation speed (and therefore half animation time) set this value to 2.

6. Record animation

Modify the video settings to meet your requirements:

Dimension
Width and height of the movie in pixel. You can either enter a size directly or select a predefined size from the list.

Note:
If the selected dimension is smaller than the dimension of the object view window it's likely that the scene

will not fit into the video. To solve this problem please adjust the parameter "Scene scale" of the virtual camera in the object inspector.

Dots per inch
Default value is 96 DPI (equal to the DPI of the screen). To get best results you should set this value to the DPI value of the target screen.

Frames per second
Default value is 25. A lower frames per second rate will lead into smaller video files but the playback will be less fluently.

Compression
You can decide which compression should be used to create the video file. When you select "**Default**" the default video codec of the system will be used. To force the usage of a particular video codec please select the entry "**Select...**". When the generation of the video file is started you will be asked for the video codec.

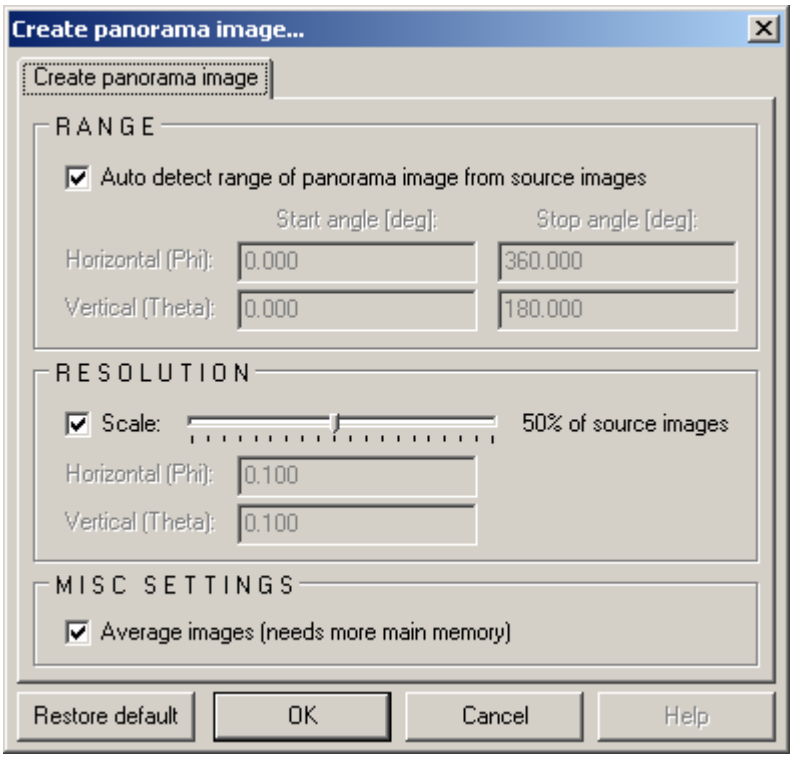
Finally start the generation of the video file by clicking on the button "**Record**". A dialog comes up where you have to enter the filename of the video file to create. The animation dialog disappears and a small window in the bottom left corner appears where you can watch the progress of the creation process. You can pause the record by clicking on "**Pause**" in order to make changed to e.g. the draw mode of some objects or show/hide some objects. To restart the record click on the button "Record" again. To completely stop the record click on the button "**Stop**".

7.8 Panorama images

RiSCAN PRO offers the possibility to create panorama images. These panorama images are generated by concatenating the images acquired at one scanposition. This is done by projecting all images onto the inner surface of a virtual sphere.

Create panorama images

To create a panorama image, select the desired images of one scanposition, click with the right mouse button on them and select "Create panorama image…" from the menu. The following dialog appears:



Range

In this section you can define the angular extensions of the panorama image in phi (horizontal) and theta (vertical) direction. If you want to have this values determined automatically from the selected images, activate the option "Auto detect range of panorama image from source images".

Resolution

In this section you can define the angular resolution of the panorama image in phi (horizontal) and theta (vertical) direction. You can either enter these values directly or activate the option "Scale". In the latter case you can define the scale factor relative to the resolution of the source images.

Note: Be careful with setting the resolution! Too high resolution (low values) will lead into enormous main memory consumption and long calculation times.

Misc settings

Activate "Average images" in order to reduce nasty transitions between two neighboring images with different brightness. This is done by calculating the average of all relevant source pixels for the particular pixel of the panorama image.

Note: This function needs much more memory and is no guarantee to eliminate the effect. Please set the camera to use constant exposure time in order to avoid the effect.

To finally create the panorama image click on the button "OK". You will be prompted to enter a file name for the panorama image. Afterwards the calculation process starts.

Part VIII

Data exchange

8 Data exchange

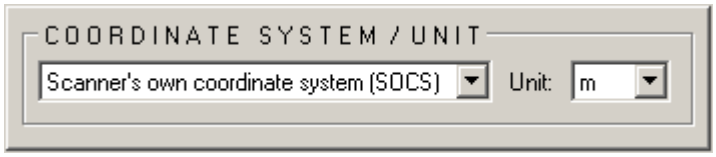
8.1 Import

You can import some different file formats. To do so just right-click on a "POLYDATA" folder and choose "Import..." from the menu.
Select a file and the desired input format from the list.

For details about the input formats and their settings please refer to the specific chapters:

- ASCII (*.*)
- point cloud (*.3pf)
- Polyworks (*.pol)
- STL (*.stl)
- PLY (*.ply)
- Documents 191

It is possible to define the source coordinate system and the source unit for every import (unit is not available for ASCII import).



Choose the type of coordinate system and unit:

- Scanner's own coordinate system (SOCS)
- Project coordinate system (PRCS)
- Global coordinate system (GLCS)

8.1.1 ASCII

The import dialog allows to import a lot of different formated data files.

The settings you have to make in order to import an ASCII file are:

Skip lines (optional):
This causes the import function to ignore the first n lines from the file (e.g. this is just a comment or anything else...).

Comment tag (optional):
Lines beginning with that character(s) will be ignored

Column separator:
You have to set the column separator to the correct character in order to recognize the data columns from the file. Normally this is the comma (","). If you don't know the column separator you can try to click on the button "Auto detect". This function attempts to find the correct character. Note, that this function may get wrong results in very "noisy" files.
You can check the right setting of the column separator in the preview located on the bottom of the dialog.

Column association:
After the column separator was set and you got a correct preview you can associate the columns. This is needed in order to tell RiSCAN PRO which column of the file contains which data. Just drag the column from the list-box

showing all columns and drop it on the corresponding column of the preview.

After all settings are made it is possible to save the settings. This provides faster import by just selecting one of the pre-defined format settings from the drop-down list on the top of the dialog. To save the settings click on the button with the plus ("+") on it. You will be prompted for a name. Enter the name (Info: Adding "Default" to one of the names will cause RiSCAN PRO to use this pre-defined format settings as default) and click on "OK" .
Wrong, or out of date pre-defined format settings can be deleted by selecting them one by one from the drop-down-list and clicking on the button with the minus on it.

To finally import the ASCII file click on the button "OK" on the bottom of the dialog.

8.1.2 Documents

You can also import documents of any file type into a RiSCAN PRO project. To do, so please create a folder within the project first by right clicking on the project and selecting "New folder" from the menu. This will create new folder within the project.

Import documents:

To import documents click with the right mouse button onto the folder and select "Import..." from the menu. Select the file to import. The file will be copied into the project. When you double click on the file in the project manager, the application registered to this file type is started and the file is loaded.

Create links:

You can also create links to files either locally saved or on the internet. To do so click with right mouse button onto the folder and select "New url..." from the menu. Enter the url either manually or drag and drop a file or link from the Windows explorer.

8.1.3 Aerial views

RiSCAN PRO offers the possibility to import aerial views and display them together with the acquired scan data.

To import an aerial view click with the right mouse button on the folder "OBJECTS / ORTHOPHOTOS" and select "Import...". Select the aerial view you want to import.

Note:
In addition to the image file a so called "world file 197" with the same name must be available. This file contains the position and orientation of the aerial view. The project has to be registered to the global coordinate system (GLCS) in order to import the aerial view correctly.

To view the aerial view just drag it from the project manager and drop it onto an opened object view.

8.2 Export

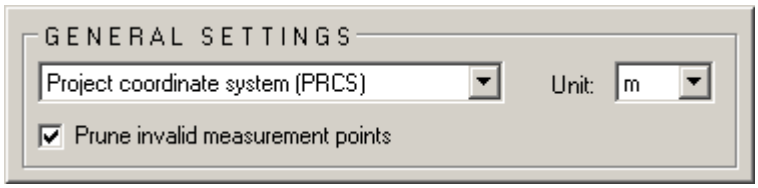
You can export some objects. To do so just right-click on it and choose "Export" from the menu.
Select a filename and the desired output format from the list.

For details about the output formats and their settings please refer to the specific chapters:

- ASCII (*.*)
- Crystalix (*.asc)
- 3DD with SOP (*.3DD)
- point cloud 192 (*.3pf)

- Autocad 192 (*.dxf) points only
- Polyworks 193 (*.pol)
- Wavefront 193 (*.obj)
- VRML 193 (*.wrl)
- PLY 193 (*.ply)
- STL 193 (*.stl)

It is possible to define the target coordinate system and the target unit for every export (unit is not available for ASCII export).



GENERAL SETTINGS

- **Choose the type of coordinate system and unit:**
  - Scanner's own coordinate system (SOCS)
  - Project coordinate system (PRCS)
  - Global coordinate system (GLCS)
- **Prune invalid measurement points**

  This will ignore invalid measurement points for the export.

8.2.1 3PF

Use intensity as color
Select this to export intensity information instead of color information.

Append to existing file
Select this to append the data to an existing file.

8.2.2 DXF

Following objects could be exported as dxf:

- **Scan**
- **Polydata**
  Only point information will be exported

- **Polyline**
- **Section**
- **Plane**
  You can export multiple objects at the same time. To do so select the objects you want to export and select "Export" from the popup menu.
  Now enter a filename and decide if you want to create only one layer for all objects or a separate layer for every object.

  Note: Objects must be all of the same type.

8.2.3 OBJ

Only triangulated polydata objects could be exported in OBJ file format.

Export with texture
If the polydata object is textured, you can select if you want to export texture information.

Use intensity as color
Select this to export intensity information instead of color information.

8.2.4 POL

Only triangulated polydata objects could be exported in POL file format.

Export with texture
If the polydata object is textured, you can select if you want to export texture information.

Use intensity as color
Select this to export intensity information instead of color information.

8.2.5 VRML

Only triangulated polydata objects could be exported in VRML file format.

Export with texture
If the polydata object is textured, you can select if you want to export texture information.

Use intensity as color
Select this to export intensity information instead of color information.

8.2.6 STL

Only triangulated polydata objects could be exported in STL file format.

Select format:
- ASCII
- Binary

8.2.7 PLY

Only triangulated polydata objects could be exported in PLY file format.

Select format:
- ASCII
- Binary (Little Endian, Big Endian)

Use intensity as color
Select this to export intensity information instead of color information.

8.3 Fileformats

8.3.1 3DD

The 3DD files contain the raw data gained by the instrument. The data format is equal to the data output of the instruments. To read 3DD files please refer to the RiSCANLIB 206.

Note: There's no format difference between 3DD and 4DD files. The file extension 4DD is used for files containing more than one scan frame.

8.3.2 3PF

The 3PF file format is a very simple format for unorganized point clouds. The point cloud is saved in an binary file of following format:

Field name		Field data (hexadecimal)	Data type	Byte offset (decimal)
Header	Identifier	63	16 bytes used to identify a 3PF file	0
		59		1
		B2		2
		CC		3
		21		4
		A4		5
		35		6
		4C		7
		84		8
		C9		9
		2E		10
		E7		11
		D5		12
		EE		13
		17		14
		FD		15
	Datasize	number of bytes following the header (= n * 24)	signed 32 bit integer value	16
				17
				18
				19
Data	Data point 1	X [m]	32 bit float value	20
		Y [m]	32 bit float value	24
		Z [m]	32 bit float value	28
		Red [0..1]	32 bit float value	32
		Green [0..1]	32 bit float value	36
		Blue [0..1]	32 bit float value	40
	Data point 2	X [m]	32 bit float value	44
		Y [m]	32 bit float value	48
		Z [m]	32 bit float value	52
		Red [0..1]	32 bit float value	56
		Green [0..1]	32 bit float value	60
		Blue [0..1]	32 bit float value	64
	...			
	Data point n	X [m]	32 bit float value	(n-1) * 24 + 20
		Y [m]	32 bit float value	(n-1) * 24 + 24
		Z [m]	32 bit float value	(n-1) * 24 + 28
		Red [0..1]	32 bit float value	(n-1) * 24 + 32
		Green [0..1]	32 bit float value	(n-1) * 24 + 36
		Blue [0..1]	32 bit float value	(n-1) * 24 + 40

8.3.3 COP, SOP, POP

The COP, SOP, POP file format is used by RiSCAN PRO to exchange matrices. This format is already known from 3D-RiSCAN / LPMSCAN.

Example of a POP Matrix exported as .POP file:

```
[tiltmatrix]
c00=0.65922099
c01=0.69496346
c02=-0.28714722
c10=-0.72800934
c11=0.68545556
c12=-0.01237154
c20=0.18822891
c21=0.21720143
c22=0.95780659
[position]
x=1040.33007813
y=1142.82165527
z=1002.35168457
```

Where c00..c22 and x, y, z correspond with following matrix values:

c00	c10	c20	x
c01	c11	c21	y
c02	c12	c22	z
0	0	0	1

Note: The offset is always in unit [m].

see also Fileformats: DAT 196

8.3.4 DAT

The DAT file format is used by RiSCAN PRO to exchange matrices. It is a very simple format using a text file. The matrix will be written into the file "as is".

Example of a POP - Matrix exported as .DAT file:

```
 0.65922099   -0.72800934    0.18822891  1040.33007813
 0.69496346    0.68545556    0.21720143  1142.82165527
-0.28714722   -0.01237154    0.95780659  1002.35168457
 0.00000000    0.00000000    0.00000000     1.00000000
```

The columns are separated by at least one blank. The lines are separated by a sequence of CR (ASCII character 13) and LF (ASCII character 10).

see also Fileformats: COP, SOP, POP 195

8.3.5 ROT

The ROT file format is used by the Multiple SOP export 14 tool of RiSCAN PRO to save the matrices. The ROT file is a text file of following format:

```
Rotation about Z axis<CR><LF>
Rotation about X axis<CR><LF>
Rotation about Y axis<CR><LF>
<CR><LF>
Translation along X axis<CR><LF>
Translation along Y axis<CR><LF>
Translation along Z axis<CR><LF>
```

Units:
Rotation in [rad]
Translation in [m]

8.3.6 RSP (Project file)

The project is saved in a text file with XML syntax (project.rsp). For a description on how data is saved see "project.pdf" which is installed in the program folder of RiSCAN PRO. Please also refer to the comments in "project.dtd" to get a description of each XML-tag. The project.dtd file is saved to each project and can also be found in the program folder of RiSCAN PRO.

8.3.7 UDA

The UDA file format is a very simple file format used by RiSCAN PRO to import position information from (D)GPS receivers. The file format is defined as follows:

```
NameOfPosition01,X,Y,Z<CR><LF>
NameOfPosition02,X,Y,Z<CR><LF>
...
```

The unit of the coordinates is defined by the unit set in the program settings 24.

8.3.8 VTP

RiSCAN PRO uses the XML based file format VTP out of the Visualization Toolkit (VTK) 207 which is open source, to save both point clouds and triangulated surfaces.

A detailed description of the VTP format can be found at: **http://vtk.org/VTK/pdf/file-formats.pdf**

RiSCAN PRO uses the standard arrays of the VTP format to save points and triangles (arrays "Points", "Verts", "Polys"). Additional information is saved in two more arrays within the tag "<PointData>". The arrays are named "intensity" and "color" and contain the intensity and color information for each point.

8.3.9 World file

Aerial views 191 are stored as raster data, where each cell in the image has a row and column number. In order to display these images it is necessary to establish an image-to-world transformation that converts the image coordinates to real-world coordinates. This transformation information is typically stored in a separate ASCII file. This file is generally referred to as the world file, since it contains the real-world transformation information used by the image. World files can be created with any text editor.

World file naming conventions

It's easy to identify the world file which should accompany an image file: world files use the same name as the image, with a "w" appended. For example, the world file for the image file mytown.tiff would be called mytown.tiffw and the world file for redlands.rlc would be redlands.rlcw. For workspaces that must adhere to the 8.3 naming convention, the first and third characters of the image file's suffix and a final "w" are used for the world file suffix. Therefore, if mytown.tif were in a an 8.3 format workspace, the world file would be mytown.tfw. If redlands.rlc was in an 8.3 format workspace, its world file would be relands.rcw. For images that lack an extension, or have an extension that is shorter than three characters, the "w" is added to the end of the file name without altering it. Therefore the world file for the image file terrain would be terrainw; the world file for the image file floorpln.rs would be floorpln.rsw.

World file contents

The contents of the world file will look something like this:

20.17541308822119
0.00000000000000
0.00000000000000
-20.17541308822119
424178.11472601280548
4313415.90726399607956

The image-to-world transformation is a six-parameter affine transformation in the form of:

x1 = Ax + By + C
y1 = Dx + Ey + F

where

x1 = calculated x-coordinate of the pixel on the map
y1 = calculated y-coordinate of the pixel on the map

x = column number of a pixel in the image
y = row number of a pixel in the image

A = x-scale; dimension of a pixel in map units in x direction
B, D = rotation terms
C, F = translation terms
E = negative of y-scale; dimension of a pixel in map units in y direction
x,y = map coordinates of the center of the upper-left pixel

Note The y-scale (E) is negative because the origins of an image and a geographic coordinate system are different. The origin of an image is located in the upper-left corner, whereas the origin of the map coordinate system is located in the lower-left corner. Row values in the image increase from the origin downward, while y-coordinate values in the map increase from the origin upward.

The transformation parameters are stored in the world file in this order:

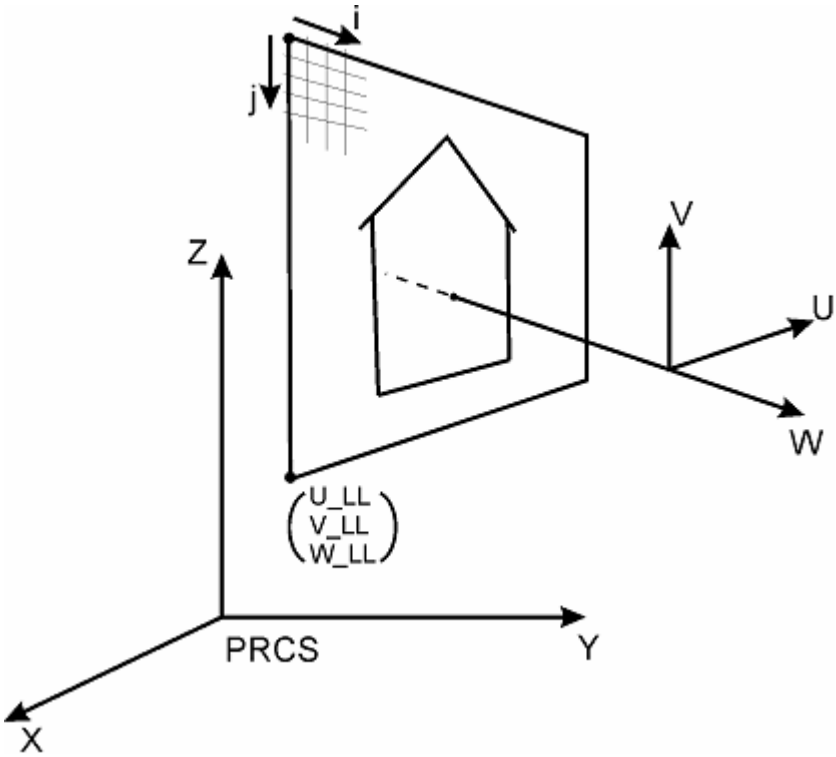
20.17541308822119 - A
0.00000000000000 - D
0.00000000000000 - B
-20.17541308822119 - E
424178.11472601280548 - C
4313415.90726399607956 - F

8.3.10 ZOP

The format is defined to describe true orthophotos with depth information. The true orthophoto is stored in a bitmap file (extension BMP) whereas the depth information is contained in a separate file with extension ZOP.

The ZOP file contains the depth for every pixel of the bitmap as a signed 16 bit integer value. The ZOP file starts with a header containing the information where and how the orthophoto is positioned and orientated in the project coordinate system (PRCS) and additional information on the pixel size and data size.

The orthophoto is defined in an UVW coordinate system as sketched below:



The drawing plane of the bitmap is parallel to the UV plane.

The lower left corner of the orthophoto is specified in the header in the UVW system by U_LL, V_LL, W_LL. The origin of the UVW system in PRCS is specified by X0, Y0, Z0. The rotation matrix is specified by nine parameters r11 to r33.

Please note that the bitmap information is stored in the bitmap file starting at the upper left corner. The pixels are contained in a line-by-line order. Pixels in a line are contained from left to right and lines are contained from top to bottom. The depth information in the ZOP file follows the same order, left to right and top to bottom.

Given the pixel coordinates in the orthophoto i and j with i defined increasing from left to right and j increasing from top to bottom, the coordinates in the UVW system are computed by

$$P_{UVW} = \begin{pmatrix} u \\ v \\ w \end{pmatrix} = \begin{pmatrix} (i + 0.5) \times \text{PIX\_SIZE} \\ (\text{B\_HEIGHT} - j - 0.5) \times \text{PIX\_SIZE} \\ \text{Z\_DEPTH}[i + j\,\text{B\_WIDTH}] \times \text{ZUNIT\_SIZE} \end{pmatrix} + \begin{pmatrix} \text{U\_LL} \\ \text{V\_LL} \\ \text{W\_LL} \end{pmatrix}$$

By forming a rotation matrix R_{ZOP} and a translation vector

$$R_{ZOP} = \begin{pmatrix} r11 & r12 & r13 \\ r21 & r22 & r23 \\ r31 & r32 & r33 \end{pmatrix}, T_{ZOP} = \begin{pmatrix} X0 \\ Y0 \\ Z0 \end{pmatrix}$$

every point in UVW, i.e.

$P_{UVW} = (u, v, w)^T$,

is transformed into PRCS by

$$P_{PRCS} = (x, y, z)^T = R_{ZOP} P_{UVW} + T_{ZOP}$$

The ZOP file is organized in records of 2 byte length. When interpreting a record or a sequence of records, byte order is in low byte high byte order, also addressed as little endian notation.

Record Position	Type	Parameter	Remarks
0	Unsigned integer (16 bit)	H_LENGTH	Length of header in units of 2 bytes, i.e., 64
1	Signed integer (16 bit)	Z_INVALID	Value of z depth indicating that there is no depth value, usually –32767 in decimal notation
2	Unsigned integer (32 bit)	B_WIDTH	Bit map width in pixels
4	Unsigned integer (32 bit)	B_HEIGHT	Bit map height in pixels
6	Single precision float	U_LL	Lower left corner of drawing plane in UVW system, U coordinate
8	Single precision float	V_LL	Lower left corner of drawing plane in UVW system, V coordinate
10	Single precision float	W_LL	Lower left corner of drawing plane in UVW system, W coordinate
12	Single precision float	PIX_SIZE	Size of a pixel in UV direction in meters
14	Single precision float	ZUNIT_SIZE	Size of Z - depth unit in meters
16	Double precision float	X0	Origin of UVW system in PRCS
20	Double precision float	Y0	Origin of UVW system in PRCS
24	Double precision float	Z0	Origin of UVW system in PRCS
28	Double precision float	r11	Coefficient of rotational matrix
32	Double precision float	r12	Coefficient of rotational matrix
36	Double precision float	r13	Coefficient of rotational matrix
40	Double precision float	r21	Coefficient of rotational matrix
44	Double precision float	r22	Coefficient of rotational matrix
48	Double precision float	r23	Coefficient of rotational matrix
52	Double precision float	r31	Coefficient of rotational matrix
56	Double precision float	r32	Coefficient of rotational matrix
60	Double precision float	r33	Coefficient of rotational matrix
H_LENGTH	Signed integer (16 bit)	Z_DEPTH(0)	Depth value corresponding to upper left pixel of orthophoto
H_LENGTH + 1	Signed integer (16 bit)	Z_DEPTH(1)	Depth value corresponding to pixel neighbouring upper left pixel to the right, i.e., in the upper most line of image
…			
H_LENGTH + (B_WIDTH B_HEIGHT – 1)	Signed integer (16 bit)	Z_DEPTH(B_WIDTH B_HEIGHT – 1)	Depth value corresponding to lower right pixel of orthophoto

Part

Appendix

9 Appendix

9.1 Download information

RiSCAN PRO Download information:

On the following web page you'll find the latest version of RiSCAN PRO as well as RiSCAN PRO documentation, plugins and tools:

http://www.riegl.com/downloads/restricted/riscan_pro.htm

When prompted for a username enter: 3DRIC
When prompted for a password enter: Z210LPM

If you have any further questions, please contact: support@riegl.co.at

9.2 Abbreviations

Abbreviations used by RiSCAN PRO and the documentation in alphabetical order:

- **CMCS**
  Abbreviation for "**C**amera **C**oordinate **S**ystem". See "Coordinate systems used / CMCS 30" for more information
- **COP**
  Abbreviation for "**C**amera **O**rientation and **P**osition" (note that COP has different meaning when applied to images depending whether the camera was mounted on top of a scanner or not - see "Embedding images into the project").
- **CR**

  Character "carriage return" (ASCII character 13)
- **GLCS**
  Abbreviation for "**G**lobal **O**wn **C**oordinate **S**ystem". See "Coordinate systems used / GLCS 30" for more information.
- **LF**

  Character "line feed" (ASCII character 10)
- **POP**
  Abbreviation for "**P**roject **O**rientation and **P**osition" (Orientation and Position of PRCS within GLCS).
- **PRCS**
  Abbreviation for "**P**roject **C**oordinate **S**ystem". See "Coordinate systems used / PRCS 30" for more information.
- **SOCS**
  Abbreviation for "**S**canner's **O**wn **C**oordinate **S**ystem". See "Coordinate systems used / SOCS 30" for more information.

- **SOP**
  Abbreviation for "**S**ensor's **O**rientation and **P**osition" (within PRCS).

- **TP**
  Abbreviation for tiepoint. In RiSCAN PRO points of interest (e.g. reflector targets) are called "tiepoints" these points are managed in tiepoint lists 78 (see "The tiepointlist window" 78).

- **TPL**
  Abbreviation for tiepointlist. A tiepointlist holds a set of tiepoints.
  Related topics:
  - The tiepointlist window 78
  - Registration via tiepoints 125

9.3 Angle definition

- Phi-, azimuth- and frame angles

  have the same meanings and refer to the horizontal alignment.

- Theta-, polar- and line angles

  have the same meanings and refer to the vertical alignment.

9.4 Program shortcuts

The following shortcuts are program wide functional:

General program shortcuts:

Action	Key	Comment
Show help file	F1	
Rename	F2	Rename currently selected item.
Create new scanposition	F6	A project must be opened.
New single scan	F7	The scan will be added to the activated scanposition.
Find reflectors	F8	Find reflectors of the currently selected scan.
Image acquisition	F9	The images will be added to the activated scanposition.
New project image	Ctrl + I	A project must be opened.
Open project	Ctrl + O	
Open last opened project	Ctrl + Shift ⇧ + O	
Close program	Ctrl + Q	The currently opened project will be saved and closed.
Save project	Ctrl + S	A project must be opened.
Create new objectview	Ctrl + V	A project must be opened.

Tool windows:

Action	Key	Comment
Show image browser	Ctrl + Alt + B	
Show data readout	Ctrl + Alt + D	
Show info window	Ctrl + Alt + I	
Show message list	Ctrl + Alt + M	
Show object inspector	Ctrl + Alt + O	
Show project manager	Ctrl + Alt + P	
Show thread list	Ctrl + Alt + T	
Show tiepoint display	Ctrl + Alt + V	

Window manipulation:

Action	Key	Comment
Close window	Ctrl + F4	
Next window	Ctrl + Tab	
Previous window	Ctrl + Shift + Tab	

9.5 RiPort

The RiPort driver enables application interface to RIEGL-LMS high speed Laser-Distance sensors. The Laser Sensor is connected to the PC using an ECP (Enhanced Capabilities Port), which usually is used to connect printers and page scanner devices. Since almost every new PC already is equipped with this port this is a convenient interface comparable to the widespread serial RS-232 connection. However, the ECP port exceeds the data-transfer speed of the serial interface due to the parallel transmission of information.

The parallel port originally only was able to transfer data out from the PC to a peripheral device (the printer). The port also had some control lines that could be driven by the peripheral (i.e. to signal "out of paper" condition).

Soon people used these lines to transfer information from the peripheral into the PC. Since a byte had to be split

into 2 halves, which is known as NIBBLE mode. The next step was to allow a bi-directional use of the 8 data lines which is known as BYTE mode. The latest improvement has been the ECP and EPP modes which further gain speed improvements from a hardware supported handshake concept.

The ECP mode is expected to become a operating system supported feature. The full fledged ECP mode is standardized in the IEEE-1284 document, and also defines smooth interworking of the NIBBLE BYTE and ECP modes. Since the standard is not yet implemented by the operating systems (only a subset, the NIBBLE mode already is) we decided to use the high speed features of the ECP mode without the interworking features and supply you a driver which isolate you from the need to know the details of the protocol. The interface is straight forward in use and allows us to implement more features in the future as the need arises without forcing you to rewrite your application.

9.6 RiSCANLIB

RiSCAN PRO uses the RiScanLib to communicate with the scanner devices.

Introduction of the RiSCANLIB

The Riegl LMS Scanner Library is a set of functions that will help you

- interface to a Riegl scanner via **parallel port, serial port** or **network**,
- read logged data from a **disk file**,
- decode data in a **scanner independent** manner,
- set scanner **parameters**,
- integrate the scanner interface using your preferred programming environment using **COM** technology,
- convert geometry data to **cartesian** or **spherical** coordinates (and apply corrections).

The library is packaged as COM objects, that are located in files named scannermod.dll and scancnfmod.dll. Once the library has been registered into your system, your compiler will be able to read its type library and generate the necessary interfaces. You then call the functions as if they were native functions in your programming environment (e.g Visual C++, Delphi, ...). Since the library is coded in COM technology you even will be able to create multiple instances of interfaces, as you would like when interfacing to more than one scanner at a time or when reading data files at the same time.

The library is running in a separate thread asynchronously to your application. This will ease your interface coding, since you almost never will be blocked when you call any of the interface functions, thereby avoiding the annoying hourglass cursor. To this end the library maintains an internal data buffer for storage of the scanner data, and controls access to it via a semaphore mechanism. The windows message passing system is used to inform you of the relevant events, such as start of a scan, receipt of a single scan-line or end of a scan.
A logging facility also is built into the library. You can use this feature to create files that will store any data the scanning unit is able to deliver, even if there is no interface function to directly access it. Storing the data in this native format will allow to use an even more improved version of the library without compromising compatibility.

Geometry data can be retrieved in spherical or cartesian coordinates. You choose the amount of information you need to get in a single call. You may specify to get any number from a single point up to an entire scan per call. The same is true for intensity (reflectivity) RGB (true color) or time data.

Error situations (such as end of file, wrong file or scanner types, ...) also are signaled via the windows message loop. The library even will give you a plain text message string, that can be used for display in your interface. This message string automatically will be translated to the language that is installed on your system. (currently english and german available).

The library is able to interface to the scanner data port either through a PC parallel port or a TCP/IP socket using the IB90-ETH box. On Windows NT/2000 interfacing is via device driver RiPort, resulting in very low processor overhead because of the use of interrupts. On Windows95/98 there is no device driver available, resulting in the need to constantly poll the port, thereby incurring high processor load. On Windows 95/98 in principle it is possible

to use even an simple bidirectional (not ECP capable) port. This interface however is not recommended at all since only very low data transfer rates are obtainable.
Windows95/98 also needs a further precaution since none of the resource sharing functions for the parallel port are in use. (A simultaneous print attempt might crash the system.)

For detailed information about the RiScanLib and how to use it please refer to the documentation of the RiScanLib!

9.7 Copyright remarks

9.7.1 VTK

RiSCAN PRO uses the Visualization Toolkit (VTK) which is open source.

VTK-License:

9.8 Revision history

2005-07-14 Version 1.2.0sp1:

Bugfixes:

Objectview: Pointsize/Linewidth is displayed as floating point number.

Objectview: New point/tiepoint: Update button is working now.

Problem with camera plugin concerning CANON cameras solved.

2005-06-23 Version 1.2.0:

New features:

Triangulation of arbitrary pointclouds added

Create cross sections added

Object handling in object inspector improved

Object view: zoom with mouse wheel added

"Add clean polydata function (OP_CLEAN). This function removes duplicated points and unused points. If a polydata has only points, you can specify a tolerance."

Add 3D text to object view. You can see now the name of the scanposition right of the scanner object.

Add a position object in the object view. You can handle scanpostions separately now.

Add a new info window for info text.

Calculate SOP via inclination sensors implemented

TPL2: Added function "CreatePolyline"

TPL2: Added function "CreatePlane"

TPL2: Added function "CreateBarycenter"

Add point object to "GeometryObjects".

Intersection between a polyline (with 2 points) and a plane object ---> Result: Point object, automatically added to the object view.

Add STL import.

Object view: select object with key "S" and mouse click

Object view: increase and decrease navigation speed with keys "A" and "D"

Backsight: This function is now able to use the inclination sensors by extracting the inclination values from a finescan. For that the user selects a tiepoint (with a tiepointscan).

Chart to analyse the inclination values gained by the scanner

Object view: Added 2D grid in orthomode

Delete points from scan implemented (in object view)

Objectview: fullscreen mode added

Export of planes as DXF is now possible

Planes: Display if DIP Dir und DIP Angle added

Planes: Export as ASCII und DXF

Image acquisition: Instrument position before and after image acquisition is compared now -> warning!

Locked property of objects in an objectview will now be saved.

Add tiepoints to objectview.

Support for ParamID 7.0 added

Project manager: shortcut [CTRL]+[ENTER] added: Locate file/folder in windows explorer

Project manager: shortcut [ALT]+[ENTER] added: Show file/folder attributes dialog of windows

File size included into information of scans and imags

Add ability to change axes display settings for the objectview to the options.

You can now define point/tiepoint objects within the objectview. You can also measure point coordinates.

You can change now the viewtype of multiple objects in the objectview at once.

PanoramaThread redesigned

Trash can added. Objects will be moved to the trash can than deleted permanently (configureable).

Import of any files (documents) added

Aerial views added

Changes:

ImportFunctions deactivated when only the viewer-license is installed

The objectview is now able to view also jpg orthophotos

Old 3D view replaced by object view

Import/Export functions now offer range-unit-selection

Buttons 2D->3D and 3D->2D reactivated

Backsight: User can now select a TP GLCS as Own- and Targetposition

Behaviour of image selection box (Color from images) changed: The box will automatically scroll to the first selected item.

SOP & Linked positions (tiltmount): SOPs can NOT be imported/modified when the scanposition is linked to an other scanposition now.

Behaviour of Tiltmount attributes changed: If positions use the TiltMount you can not edit the it but display it's values.

Change render algorithm.

Object inspector: Remove separate "Position" - page and move it to objects.

Assignment of reflector types: The vector of a disc will now point to the scanposition.

Display of StdDev is now also functional for TPL PRCS

Matrix compare: Display more digits

Support for instrument Z360I_NF added

COP, SOP, POP: Translation is now displayed in selected range unit

Change display of axes in objectview.

ObjectView: Switching between perspective and orthogonal view mode improved.

Create Orthophoto: This modul can now also take PRCS polydata as input.

Animation: Add plane object in arc mode to visulise the arc.

2D view: Right mouse click to open the context menu is now more movement tolerant. (3 pixel radius)

A detailscan from an other scan now uses the raw coordinates for the angle readout

DXF export: Layer will now get his name from the corresponding object (only when "use separate layers" is checked)

Associate 3DD and 3PF disabled

New about box and splash screen added

RiSCAN PRO can now also be licensed onto a USB Dongle

Enlarged number of recently opened projects to 9

CTRL+A for TPL activated

ImageBrowser now memorizes it's settings (Registry)

xOP imports/exports in the selected range unit now

Objectview: When pressing "Shift" + DefaultView-button (eg. Bird's eye view) the distance from the camera to the pickpoint is the same.

UDA import now takes care of the selected unit (program settings)

New toolbars for objectview added: - New object - Measure

UI of filter propertysheet will now be saved/loaded.

Pressing "I" and click with the left mouse button into an objectview will display some information of the point closest to the line of sight in the "info window"

Bugfixes:

New single scans: Display of values is now common.

project.dtd: camcalibtask_freeimages: image* was missing

Upgrade of mesh: Error message "Can not rename ..." fixed

Bug fixed: Camera calibration free images failed when a lot of images where used

PLY and VRML exports improved

Error message "TraceStart" when the program was started several times simultanous solved.

Bug in TP's link and backlink system fixed

Bug in desktop-settings of Objectinspector fixed

Bug in TPL import fixed: Names will be imported correctly now.

Bug in TP link system concerning the trash solved

TPL2: GSI-Import modified: Now RTP is checked first

TPL2 import: Identical name bug fixed

Bug in tiepoint attributes solved: All values have been saved when User hits [OK]. Now only modified values are saved

Bug in import of scanpositions fixed.

Bug in tiepoint attributes solved (Name wasn't saved on Init)

Bug in Resample thread fixed (result was not saved)

TPL2: Bug in "Create plane" fixed: Up vector was not correct

Bug in finescan of image TP fixed (name collision)

convert union view bug fixed

Cancel bug fixed

Find reflectors is now more tolerant in "Use TPL SOCS" mode (Reflector size < 0.05m is set to 0.05)

Bug in triangulate dialog fixed: Some checkboxes were disabled

Objectview: After SOP update the cooresponding scanposition in the view was not updated.

Bug in project load fixed: Wrong project.dtd was used!

Bug in SOP Wizard concerning inclination sensors fixed.

Bug in color thread fixed: Wrong camera calibration was used when more than two images with different calibrations were used.

Bug in filter procedure fixed

Bug in ZOP attributes solved: The rotational part of the ZOP matrix was not displayed correctly - it was transposed

Bug in project.dtd concerning camera calibration task chessboard fixed.

project.rsp: "project.dtd" replaced by "./project.dtd", because the parser was not able to find the project.dtd

file.

project.dtd problem fixed

Bug in TiepointDisplay fixed

Bug in ASCII import dialogs of polydata and tiepoints fixed: Column association was not correctly loaded from presets.

Bug in online view of scansequence fixed

TPL: Bug in StdDev calculation fixed (wrong values for links to TP GLCS)

Render: Problem with dynamic devider > 1 fixed

Bug in TP naming solved

ASCII Import improved

Bug in TPL import fixed: Empty lines caused errors.

Modify object: The rotation axis is not also updated.

scan acquisition: performance problems solved.

Bug in scan thread concerning inclination values and cache fixed.

TPL some update problems fixed

Bug in volume thread fixed: Question "Use all" was wrong evaluated

Fix problem when scan parameters was saved permanent.

ObjectView: Fix bug when defining a point in orthomode.

Improve triangulation in objectview.

Fix bug - Volumsberechnung: No points left for volume calculation.

Bug in CamCalibTaskScandataPropertySheet fixed: Wrong/No MountCalib was used

TPL PRCS: After registration to TPL GLCS the linked TP PRCS will NOT be modified anymore.

Improve rectangle filter in object view. Points behind the viewing camera was also selected.

Bug in Frame2D "Add point to TPL" fixed

OpenGL extensions for axes rendering are now checked during initialization of an objectview. If extensions are not available a warning will be displayed.

Bug in RiSCAN PRO startup fixed -> Doubleclick on rsp files produced some stange errors

2004-06-04 Version 1.1.1:

Changes:

Object view replaces UnionView

Object "Polydata" replaces "point cloud" (3PF is only supported as export and import format)

New/Improved data export functions: ASCII, 3PF, DXF-Points, 3DD with SOP, POL, OBJ, VRML, PLY, STL

New/improved data import functions: ASCII, 3PF, POL (as polydata)

Filterfunctions added (Rangegate, Intensitygate, Octree, Pointfilter); result is a "Polydata" object.

Wizard for a initial camera-calibration added.

Datareadout redesigned.

Usage of tiltmounts implemented

Hybrid Multi Station Adjustment (without using images) added

Image acquisition: pause implemented before the taking the image (user input - see options)

When an image is taken, it is checked if it has the same dimension as the selected camera calibration.

Now its possible to define a new scan from an single image (at the same position)

Added scanner control ("Tool"->"Scanner control")

Now its possible to rename the project folder (project.name is changed on opening the project)

Connection of camera is no saved to project (not program options)

Bug fixes:

Bug in Drag&Drop a TPL into a FormView solved (wrong display)

Reflector extraction based on TPL SOCS caused error when more images where selected and at least one image had it's TPL displayed.

When resampling a scan the threshold was ignored.

Bug in viewtypes fixed (intensity=0 was handled as invalid measurement)

Orient (HMSA) message window caused crash on saving [fixed]

Import CamCalib_OpenCV bug fixed

Some improvements on the registration

Some improvements on the camera server and camera client

2003-11-28 Version 1.1.0:

Changes:

Backsight-capability added

New camera-calibration based on reflector column added

New option for ASCII-Export added: ACI (AutoCAD-Color-Index).

Creation of orhtophotos (with depth-information)

Re-design of registration procedure

Bug fixes:

some general bug-fixes

2003-09-12 Version 1.0.2b30:

Changes:

The default coordinate system for the DataReadout is now PRCS!

Unionview-property-sheet redesigned

Font for "Message list" can be selected now (Options dialog)

Support for Z420I added

Added support for the Canon Powershot G3 and the Canon EOS-1 Ds.

Added a resample routine for single scans.

Added an ASCII export for single scans and point cloud

Added an Crystalix export for single scans and point cloud

Added the possibility to select several markers/tiepoints with a rectangle (Frame2D).

Two (selected) tiepoints of a 2D-view can now be linked (->context-menu) without showing the tiepointlist

UDA-Import added

Tiepointlist redesigned

"Find corresponding points:" added the possibility to clear the link (=results) before this process.

"Auto linker..." function added to Frame2D (automatical-link of a TP IMAGE and TP SOCS)

ZOP (Orthophoto) Export added

Bug-fixes:

Within the finescan of a reflector the reflector-constant was lost.

Selected TPs in a 2D-view where not allways selected in the tiepointlist

"Save as" function did not work correctly with Camera Calibration Tasks.

When use 2D filters in a view, the file reference was not set.

If during an image acquisition an error occurs, the thread got frozzen.

The export-functions of a scan/point cloud are also available now when the project is readonly.

The button "scan reflectors" in a 2D-View was shown for images also (now only for scans)!

Bug in UDA-Import fixed (to bottom-right cell of the SOP matrix was set to zero instead of 1)

The calculation of the preview image scale factor was wrong.

The calculation of the Frame2D image scale factor is wrong.

Re- Adjustment of mounting-calibration displayed (and used) to much tiepoints (also tiepoints of images, which have an other mounting-calibration assigned).

Bug in Wizard according the camera settings solved

When the attributes of an image were displayed a camera- and mounting-calibration were selected, although no calibration was assigned.

Bug in "Image acquisition" - PropertySheet: Cancel during SN-Check failed.

Bug in ReflectorCalibration W,H and D of a CUBE were not properly saved.

2003-05-30 Version 1.0.2b9:

Changes:

Added a legend panel for the unionview. Enables fast show/hide and coloring of a point cloud.

Added a new panel "Distance" to the "Readout"-window. The reference point can be set with key "D" and left mouse button in a 3D view.

Re-adjustment of mounting-matrix implemented

Position of the marker-labels can now be changed (top, middle, bottom, left, center, right). This provides better readability (two markers at same place...).

Added the scansequence functionality. Now you can acquire a series of scans. You can also calculate the average of the scansequence and convert them to one single scan.

Added a wizard: Wizard "Startup" - this will be called after the setup or by menu "?"

Add 2D filters to the 3D-view, unionview and point cloud-view. There are three filter methods: rectangle, circle and polyline. You can also invert the selection and undo the last filter action.

Readout-window: GLCS for Unionview added

The settings of the unionview propertysheet will now be saved in the project file.

Camera calibration based on flat check pattern added.

Undo function for all OP (SOP, POP, COP) added

Bug-fixes:

BoundingBox calculation was not correct, when creating a colored scan ("Color from images...").

Initial values of the 3D-view and the union-view was not set correct (e.g. "Show bounding box").

There were some navigation problems in the 3D-view and the union-view. This should now work correct.

Displaying TPL (PRCS) in 2D images of scan data raised error messages sometimes.

field of view of camera was calculated incorrectly in some cases.

Made the csv-import (TPL) more robust concerning text where no text should be.

The TPs of a SCAN were not correctly displayed when the scan-image was rotateted by 90° or 270°. Everything worked normal with 0° and 180°.

Hang-ups during "Find reflectors" twice on a scan solved.

Bug in extraction range selection during the image-reflector extraction. (when the image was rotated) solved.

Saving projects on japanese operating systems didn't work

2003-04-25 Version 1.0.1:

Bug-fixes:

Onlineview during scan hung up

Bug in file-naming convention

Selecting "Find Reflectors" when the corresponding scan was already opened caused RiSCAN PRO to hang up.

2003-04-16 Version 1.0.0:

Initial version

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